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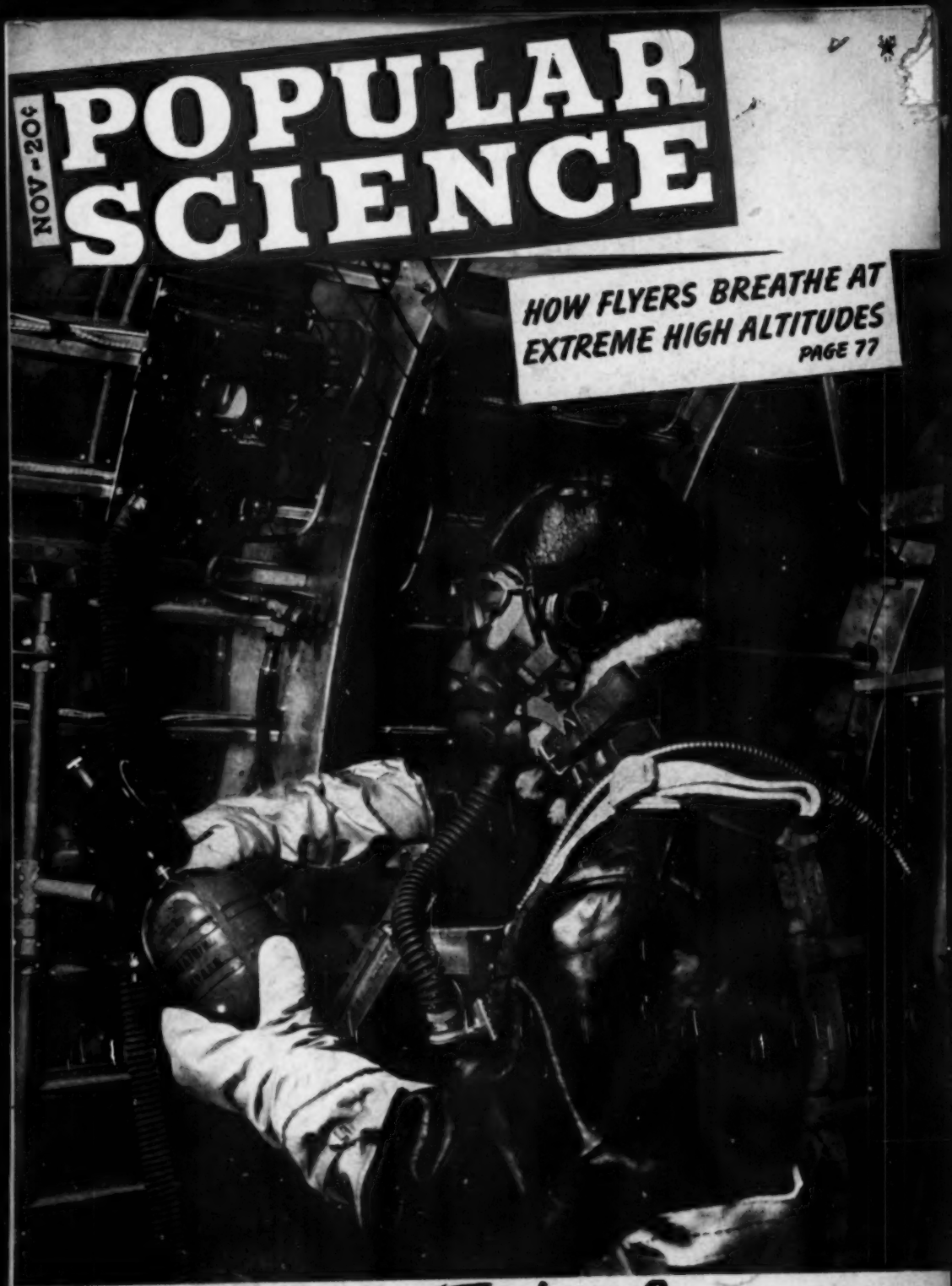

HOW FLYERS BREATHE AT EXTREME HIGH ALTITUDES
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When Russia Fights Japan
PAGE 65

Straight steer *by Fisher*

The Army-Navy "E" flies above three Fisher plants for excellence in aircraft production and from two others for tank production, while the Navy "E," with three stars, is flown by still another Fisher plant for its naval ordnance work.

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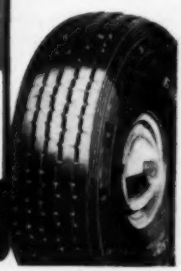

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My present job.....*Length of time with present employer*.....

The "job ahead" for which training would fit me.....

My address.....*City*.....*State*.....

POPULAR SCIENCE

FOUNDED 1872 MONTHLY VOL. 143 NO. 5

Mechanics & Handicraft

A TECHNICAL JOURNAL OF SCIENCE AND INDUSTRY

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PUTTING THE PRECISION IN PRECISION BOMBING

OUR bombardiers' boast that they can "hit a pickle barrel at 10,000 feet" is backed up by a mathematical and mechanical miracle. When a bomb is dropped from a plane traveling 200 miles an hour, miles above the earth, it is a job for an Einstein to figure just where it is going to land. Good as they are, our bombardiers are not expected to be mathematical wizards. Their amazing skill in picking off enemy factories, rail yards, and military installations is due to the wonderful tool with which they have been provided —the precision bombsight. You may have wondered how this Axis-beating instrument works. An article in our December issue will explain the complicated mathematical problems involved and the ingenious mechanism that solves them.

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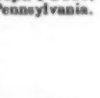

PIPER Cub

POINTS THE WAY TO WINGS FOR ALL AMERICANS

Coming Next Month

GUN POWER will make history when the Allied grand fleets force a showdown with the elusive Japanese Navy. The big rifles that speak from the turrets of our men-of-war are the most powerful instruments of destruction ever used at sea. Arthur Grahame tells how they evolved from the simple brass tubes that were the first naval artillery, 500 years ago.

MOSQUITOES have been bad in Berlin lately —not the kind that can be shoed away with a spray gun, either. They're nasty little British fighter-bombers made almost entirely of plywood and capable of hauling a troublesome amount of explosive at fighter-plane speeds. William S. Friedman tells you what you want to know about this scourge of the Nazis.

THAT POSTWAR CAR of yours—what will it look like, and how will it perform? When the automobile manufacturers get into production on new models, we can expect many radical changes. An article gives you a preview of the automobile of the near future—its design, its power plant, and the comforts and conveniences it will give the motorist. Don't miss this glimpse of the highways of tomorrow.

INVENTORS ARE EXCITED over proposed changes in our patent laws. Legislation before Congress would substitute "compulsory licensing" for the absolute control now enjoyed by inventors over their discoveries. You'll want to know the facts about this controversy. Would the proposed law remove the incentive that has made Yankee ingenuity proverbial throughout the world?

STEEL IS THE STUFF that will win the war. We hear a lot about guns, tanks, and ships, but they all go back to this raw material. To show you what steel is and where we get it, Alden P. Armagnac takes you on a tour of the flaming furnaces of "Victory Valley" on the Monongahela, one of the great steel-making centers that feed the "Arsenal of Democracy."

WHEN YOU USE A LADDER, be sure it is the right kind. Personal safety and good work both require it. If a ladder is just a ladder to you, it will pay you to read up on the subject. A practical article describes the different types, from the lowly stepladder to the long extension job, and tells which is best for each purpose.

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"GOD GEOMETRIZES," said an ancient sage. Within the straight line, curve, and angle—and their combinations—exist the forces of creation. These *secret symbols* contain the mysterious laws of the universe. Upon their right use—or the neglect of them—the success or failure of every *human enterprise* depends.

Have you a desire, *something you wish to accomplish* in life? Put your finger on a dot. In whatever direction you move your finger from the dot, you have made a beginning. Thus a dot is the symbol of *one*—or a beginning. Your desire then is also symbolized by *one*. If you follow the *proper method* or way to accomplish what you want, you have arrived at point *two*. Whenever these two symbols are brought together—the idea and the right way—you produce point *three*—the success of your plan. Success, therefore, is symbolized by the three equal sides of a *triangle*.

In planning your personal affairs—business, domestic, or the welfare of your family—do you use a *Cosmic formula?* Do you determine whether your acts are in accord with Divine truths eternally expressed in symbols? Why does the circle represent completion? Why is it said that a man is on the square? These symbols are used by astronomers and scientists to prove the physical laws of the universe—why don't you apply them to the problems of your everyday world? Learn what symbols, as powers and forces of nature, you can simply and intelligently use in directing the course of your life.

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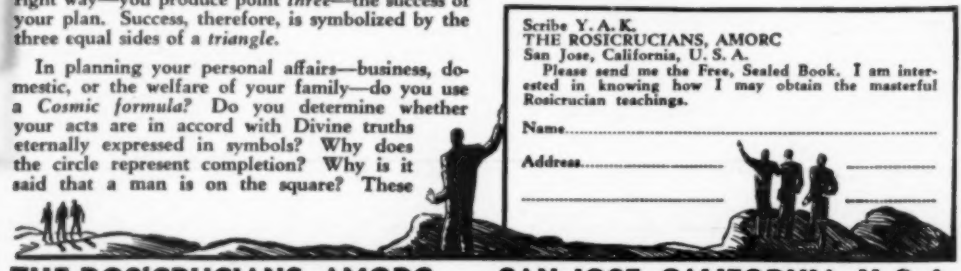

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A NEW MAN!

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Are you ALL MAN—tough-muscled, on your toes every minute, with all the up-and-at-'em that can lick your weight in wildcats? *Or do you need the help I can give you*—the help that has already worked such wonders for other fellows, everywhere?

All the world knows I was ONCE a skinny, scrawny 97-lb. weakling. And NOW it knows that I am the holder of the title, "The World's Most Perfectly Developed Man." How did I do it? How do I work miracles with the bodies of other men in only 15 minutes a day? The answer is *"Dynamic Tension,"* the amazing method I discovered and which changed me from a 97-pound weakling into the champion you see here!

In just 15 minutes a day, right in the privacy of your own home, I'm ready to prove that *"Dynamic Tension"* can lay a new outfit of solid muscle over every inch of your body. Let me put new, smashing power into your arms and shoulders—give you an armor-shield of stomach muscle—strengthen your legs into real columns of surging stamina. If lack of exercise or wrong living has weakened you *inside*, I'll get after that condition, too, and show you how it feels to LIVE!

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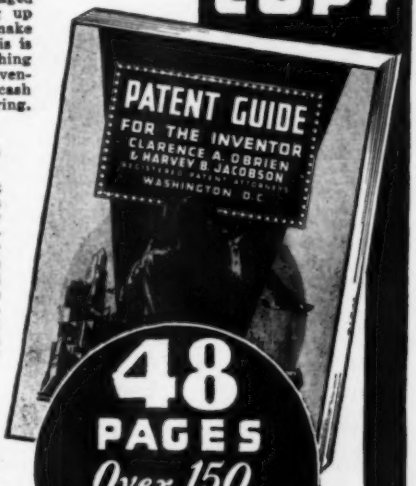

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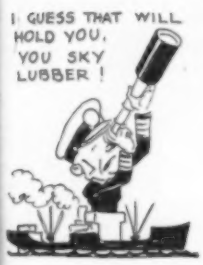
Readers Say:

Sailors Had an Easier Way of Doing It in 1897

ON PAGE 72 of your August issue, you give a vision-range formula that has been worked out by the Clipper captains of Pan American Airways. The formula is to multiply the square root of the plane's altitude by 1.225, the result being the distance that a pilot can see. Some time around 1897 I read an engineering handbook that said something to this effect: "Any intelligent officer of a ship knows that the square root of 1.5 multiplied by the height of the eye in feet is the distance of the visible horizon." I have experimented with both formulas, and I find that they give approximately the same results—only I think that the older one is easier to work with and to remember. I've remembered it for over 40 years.—W. H., Cranbrook, B. C., Canada.



Perhaps Recent Jap Reverses Are Responsible

THE LETTER of M. L. H., of Levering, Mich., in the September issue, may have been intended as a humorous contribution to your Readers Say columns, but it does not alter the fact that water that is allowed to drain undisturbed from a bathtub or similar container, will always swirl counterclockwise. Naturally, if a person puts his hand in the swirl and swings it around clockwise, he can reverse the direction of the swirl. Incidentally, here is a question I would like to put to M. L. H. If he should ever travel south of the Equator—in the South Pacific area, for example—he will find that draining water always swirls clockwise. Perhaps he can tell me why?—G. E. B., Niagara Falls, N. Y.

Hearty Approval of P.S.M.'s Two-Purpose Back Cover

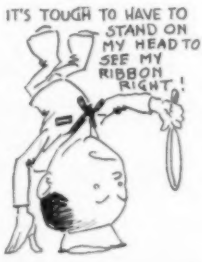
HAS ANYONE ever complimented you on your back cover, which makes such a handy marker for reading? If no one has, allow me to. I find it a special convenience, and sincerely hope that you have no intention of discontinuing this feature. I have been taking POPULAR SCIENCE for more years than I care to remember. I start at the front cover and plow straight through it. I invariably enjoy every issue.—G. M., Dover, Fla.

A Good Steer—Straight from the Manufacturer

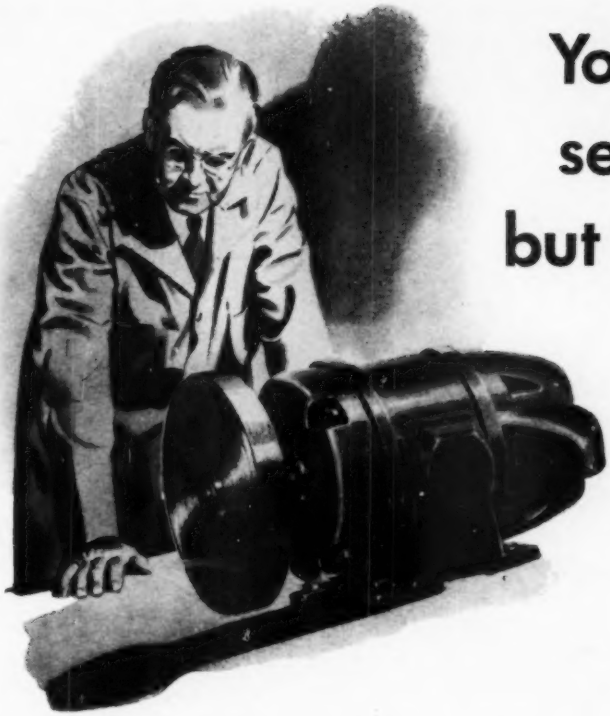
THE ARTICLE on page 129 of your September issue covering the adjustment of our automobile steering gear was naturally of great interest to us. We should like to point out, however, that to eliminate end play in the roller shaft of the Gemmer gear, the adjustment should be made with the steering wheel in mid position, as when driving straight ahead. The design of the Gemmer gear is such as to permit adjustment for wear in the center of the worm without causing binding either side of the center. If adjustment is made either side of center, however, the gear may bind in the mid position. Any backlash at either end will cause no trouble because the gears are under thrust when in the turning position.—G. B., Gemmer Manufacturing Co., Detroit, Mich.

A Torpedoed Midshipman Gets Us Right Side Up

WHILE reading through the July issue, I noticed in your article, "These Are the Badges of Courage," that your photograph of the three-striped Torpedoed Seaman Bar is upside down. The light blue stripe, representing the sky, should be at the top, and the dark blue stripe, representing the water, should be at the bottom. The red stripe in the middle stands for the action encountered. I've checked this carefully so that I am pretty sure that I've got it right. At any rate, that is the way I wear the one that was issued to me.—Cadet Midshipman W. A. P., U. S. Merchant Marine Academy, Kings Point, L. I., N. Y.



You're perfectly right, W. A. P.—and thanks. All we can say is that we're glad we at least got the red stripe in the right place.—Ed.



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THE MOST ACCURATELY machined rotating part ever built—although apparently in balance to the naked eye—may be *out of balance.*

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Readers Say:

A Lost Poem Finds Its Author

I HAVE just noticed in your "Readers Say" for July a letter from Captain A. R., of the Royal Canadian Air Force, Lachine, Quebec, concerning the poem, "A Gunner's Vow," which appeared on page 118 of your April issue. The captain is quite right about the author's initials being G. H. H. The author's full name is George Henry Harding—and I'm very proud to be able to tell you that he is my son. He wrote the poem in August, 1940, at the time he was training to be an air gunner. He was later made a pilot and then grounded because of airsickness. He is now a radio operator in the R.C.A.F. The poem, as it appears in your April issue, is incomplete. It has a first stanza which goes as follows:

If I must be a gunner,
Then please Lord grant me grace,
That I may leave this station
With a smile upon my face.

I am quoting this first stanza for you with the thought that those of your readers who enjoyed the poem as it appeared in your magazine, and who possibly have made copies of it, might like to have the poem in its entirety.—Mrs. G. H., London, Ont., Canada.

Five Sons Keep Ma Hep to Jeeps

WHEN the war is over we shall see the jeep doing more work in civilian life than it did in the service. It is bound to be a vital machine on farms, in logging camps, in oil fields, and in mining districts. In metropolitan areas it will be every busy business man's first aid to success. P.S. I have seven sons—five in the armed forces, and two about to enter. That's why I know so much about jeeps.—Mrs. W. M. F., Cleburne, Tex.

We Fielded This One Without an Error

IN THE article, "Big Leagues Get a War Baseball," which appeared in your July issue, you state that A. G. Spalding & Bros., make all the baseballs used in the major leagues. Yet in the photograph in the lower right-hand corner of page 47 you show a National League ball with Spalding's trademark and an American League ball with Reach's trademark. How about that?—B. B., Greensboro, N. C.

Very simple, B. B.—Spalding uses two trademarks: one for the National League, one for the American. The balls are identical—with, of course, the exception of the trademark.—Ed.

We Didn't Mean to Be So Tough on Boules

IN LOOKING over the January issue of your magazine, I noticed in your article entitled "Synthetic Jewels," that you have given the Mohs hardness of aluminum oxide boules as 9.3. As director of research for a company engaged in the manufacture of abrasives and refractory materials, I have reason to believe that this figure is incorrect. I know that the boules are hard, but I don't think they are quite that hard.—R. C. B., Niagara Falls, N. Y.

You're right, R. C. B. The figure should be 9.03. Thank you for calling the error to our attention.—Ed.

For Old X-Ray Negatives —Alcohol in Moderation

IF J. A. K., of Nashville, Tenn., whose letter appeared in your August issue, will wipe his old X-ray negatives with a cloth that has been dampened with ordinary "rubbing" alcohol, he will find that this thoroughly cleans the film. He must be careful, however, not to douse the cloth too heavily with alcohol, else the gelatine base is likely to become mushy.—T. J. L., Minneapolis, Minn.

Heroes' Alma Mater

Our airmen have proved themselves masters of anything that flies.

When you hear of their exploits you wonder how such skill, such devastating dexterity could be acquired in a few brief months. Surely, these men must have been "born to the blue."

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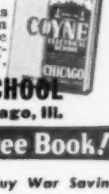

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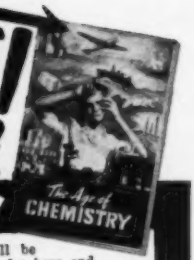

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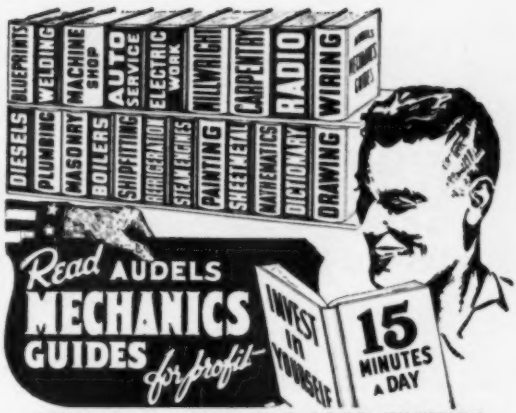

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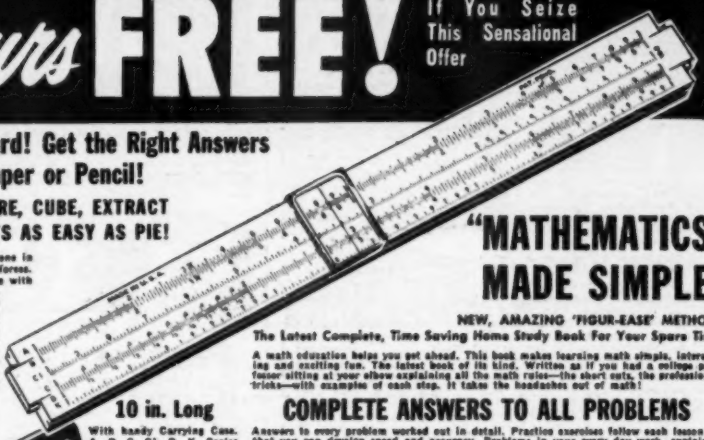

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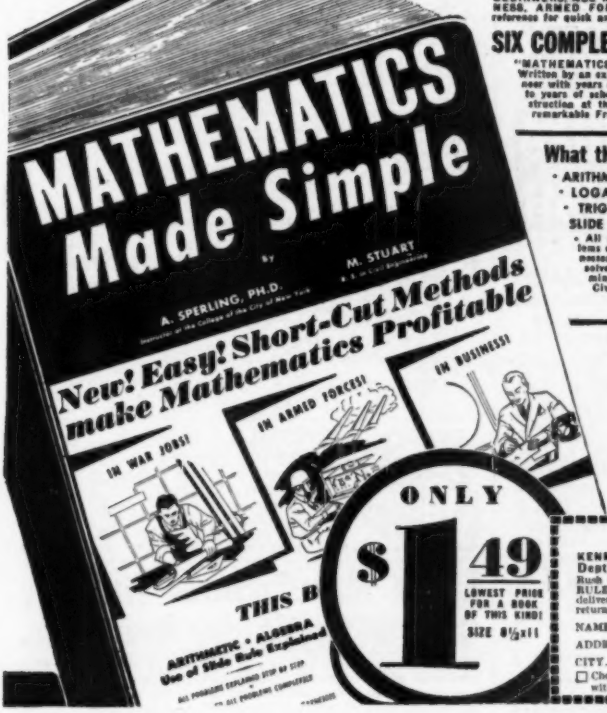

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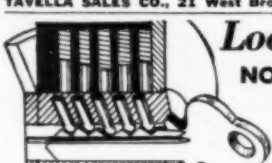

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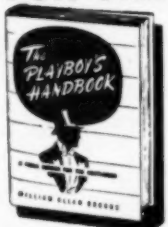

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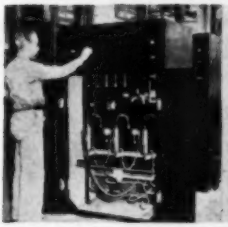

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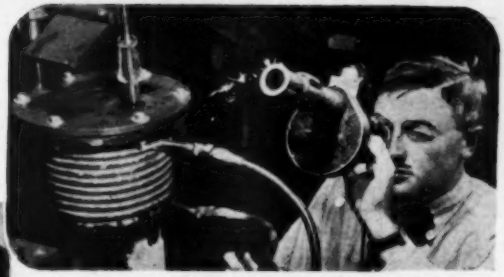

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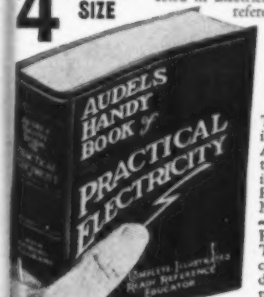

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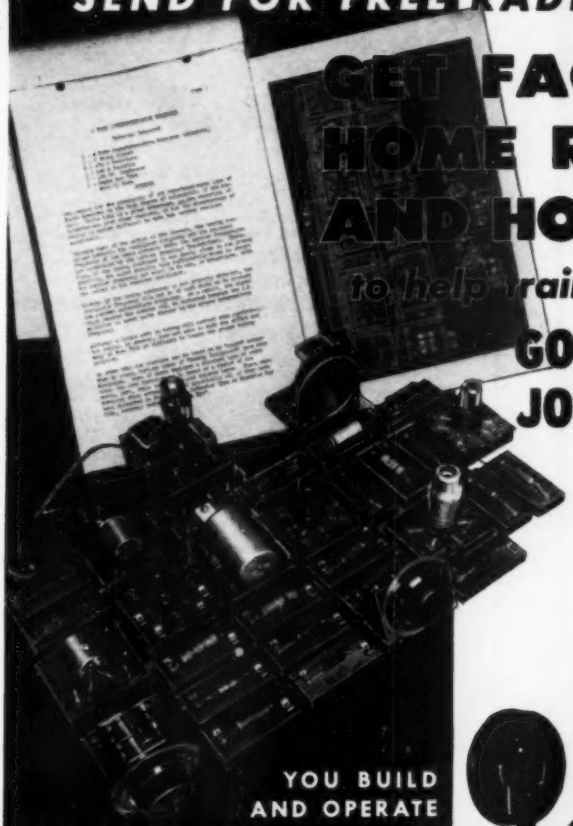

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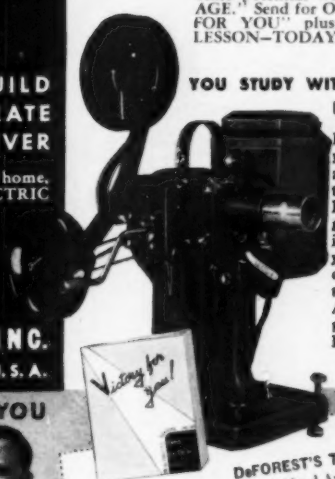

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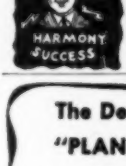

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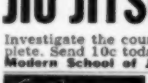

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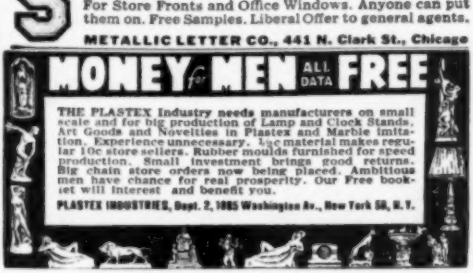

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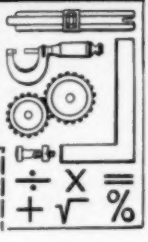

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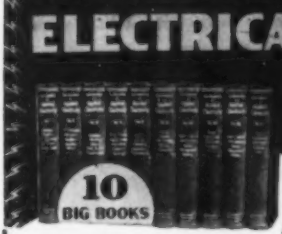

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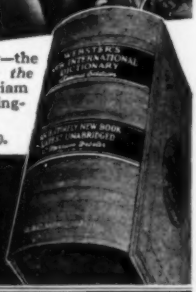

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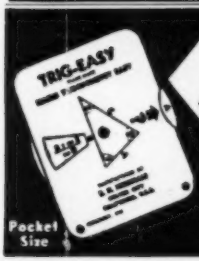

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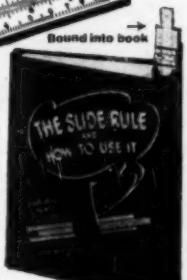

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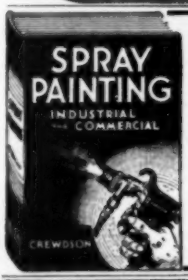

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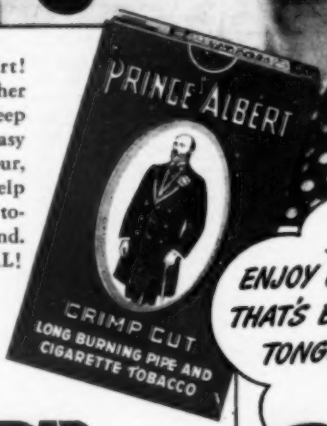

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Planes Back Up Ground Forces in
OUR NEW THEORY OF AIR POWER

BATTLES ARE NOW FOUGHT IN THREE DIMENSIONS AS FLYERS LEND SUPPORT WITH BOMBS, GUNS, AND CAMERAS

By JOHN H. WALKER

ALLIED victory in Africa and again in Sicily—first steppingstone to the invasion of Europe—was prepared and consummated under the protective web of air power, superbly co-ordinated with the attacks of the decisive ground forces and the maintenance of the essential sea lanes.

On one field of battle after another, the story was told: Allied heavy bombers plastering the enemy's rear-area air bases and supply ports; Allied medium bombers blasting his advanced fighter bases, tank columns, and infantry reserves on the roads; Allied dive and glide and fighter bombers slashing and strafing at his forward lines and strong points.

This expert collaboration between air and ground forces is the fruit of a new theory and technique in the use of air power. Developed by both the British and American air forces, this theory recognizes two basic kinds of support that air power can give to ground power. In Africa it found expression in the division of our air strength into *Strategic* and *Tactical* Air Forces. Its success marks it as the pattern for the future employment of the air arm and as one of the most impor-

THIS IS A TYPICAL SETUP FOR AN AIR-SUPPORT CONTROL POST

COMMUNICATIONS lines are laid by a wire tosser mounted on a jeep. Carrying two reels with a mile of wire on each, it can string line at 30 miles an hour. Here the end of the wire is being anchored to a tree at the beginning of a run

RADIOTELEPHONE OPERATOR sends messages by remote control through the transmitter, perhaps several miles away. Set is powered by batteries

TRANSMITTER is camouflaged carefully to prevent destruction by the enemy. Carried by a 1½-ton truck and trailer with gasoline-powered generator, it handles messages by remote control, monitors planes, airfields, and headquarters. Its crew of two men serve as drivers, technicians, radio electricians. If it is knocked out, the operational truck can send directly

tant recent developments in the art of war.

Strategic air power, in this technical sense, is represented mainly by large bombers, flying relatively long distances to strike the enemy in his home areas—war industries, communications, ammunition depots, barracks, port facilities. This can be a form of air support, as when Maj. Gen. Jimmy Doolittle's heavy bombers crippled the Axis African air force by bombing out the support fields in Sicily and Southern Italy. But it also may function independently, as in the strategic bombing of Germany by the RAF and the U. S. Eighth Air Force.

Air support in its purest, most direct form, is the job of *tactical* air power. No fixed limit is applied on space, although airmen have a rule of thumb that tactical operations will not usually penetrate farther than 150 miles into the enemy's territory.

The British called this type of air power "close support," although no one has yet been able to give a satisfactory answer to the inevitable question, "How close is close?" Its main work is the bombing and strafing of the enemy at the precise time and place that will assist infantry or armored troops to overcome local resistance.

The old notion that air-ground support was entirely confined to light and dive bombardment has been completely overthrown. Any bomber, up to the giant B-17's and B-24's, may be used on a support mission. As a matter of military economy, however, light or medium bombers usually can perform an air-support assignment with greater speed and efficiency.

Air support can use a fighter plane to

Photographs by
WILLIAM W. MORRIS

CONTROL unit is housed in the operational truck and a tent, both equipped for blackouts. It maintains constant communication with planes, headquarters, and airfields. Setup is typical for area where ground forces are making attack

COMMAND of the control unit, below, is a clearing house for information gathered by air and ground reconnaissance, requests from headquarters for attack missions, and reports of attacks made. Such a unit usually serves for a division

TELETYPE affords direct communication with headquarters and airfields, with a permanent record at both ends to reduce chances of errors and misunderstandings. Three men operate the machine carried in the control truck. Telephone and radio can be used to supplement the teletype

strafe the enemy, a glide or low-level bomber to drop delayed-action bombs on his columns, a dive bomber to plunk a load of high explosive on a strong point, a medium bomber to lay a stick or a salvo of ruin across a fortified position, or let down a string of delayed-action parachute bombs in a low-altitude sweep across a troop or truck concentration.

Liaison and reconnaissance planes complete the list of air equipment used, with all types represented from tiny "grasshopper" planes that can land and take off in open fields, to converted twin-engined Lightning fighters that can outpace or outclimb anything the enemy could put in the air.

Men and planes do the fighting, but the lifeblood of their work is communications, and here again every method is put to use, from the simple act of waggling a plane's wings or dropping a message, to the most highly developed radio and wire equipment.

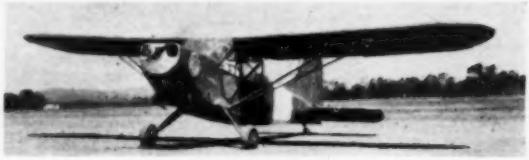
Basic communications from headquarters to air bases are carried out by teletype wherever possible. Teletype is unique in providing both ends with an instantaneous, permanent copy of the order or message, thus cutting the chance of error or misunderstanding down close to zero. The telephone and radio circuits supplement this, and radio naturally is invaluable for communication with planes in flight, when plans must be altered at the last moment.

Wire-tossing jeeps that lay phone and teletype wires at 30 miles an hour help keep the communications system functioning even during periods of rapid movement. Radio communication in the field is carried on

AIR SUPPORT PERFORMS MANY IMPORTANT JOBS

TRANSPORT. Big C-47 transport planes like these carry paratroopers and tow gliders loaded with airborne troops far behind the enemy's lines. They also bring in important personnel and supplies, evacuate wounded

LIAISON. Tiny "grasshopper" planes carry messages and transport officers behind the lines. Equipped with radiotelephone, they can perform reconnaissance in cases where high speed and armament are not needed for defense



mainly through a series of highly ingenious trailer trucks evolved by the Air Forces. The trailers carry their own generators, but tap into power lines where they are available. If the enemy air force is operating in strength, wire can be laid and the entire trailer operation carried on by remote control, with as much as seven miles between the broadcasting unit (which might be spotted by enemy radio direction finders) and the operational unit which is originating the messages. If the remote-control truck is knocked out by enemy bombing or artillery fire, the operational truck has duplicate sending and receiving equipment to continue work.

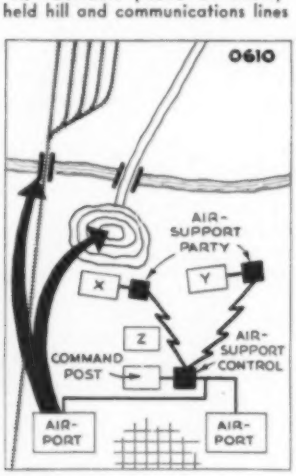
Into these communications centers pours the endless flood of battle information—requests from headquarters for attack missions, reports of attacks carried out, and disposition of enemy units observed by reconnaissance aircraft.

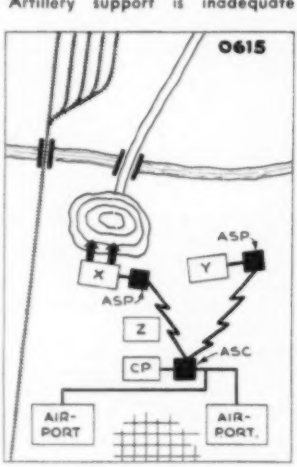
Liaison between air and ground forces is effected by the assignment of air officers to work in co-operation with the g ound commanders. An Air Support Command normally is set up to function with an army or corps in the field. An Air Support Control works with a smaller unit, usually a division; a typical Control would include three officers and ten enlisted men with their communications *(Continued on page 202)*

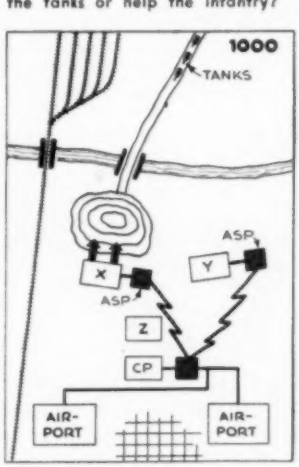
BATTLE SUPPORT. Preparing for an attack by a combat team "X," bombers pound an enemy-held hill and communications lines

Infantry attack is launched. Team "X" meets unexpectedly stiff resistance by mortars, field guns. Artillery support is inadequate

Air reconnaissance reports heavy enemy armored striking force is coming up. Shall air support hit the tanks or help the infantry?







FOR THE GROUND FORCES

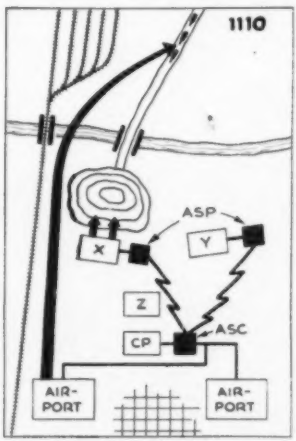
PHOTOGRAPHY plays a big part in air reconnaissance. Pictures developed in the field are sent by wirephoto transmitter to headquarters, where maps are corrected accordingly. The two prints below show a crossroads as shot obliquely from a low-flying reconnaissance plane

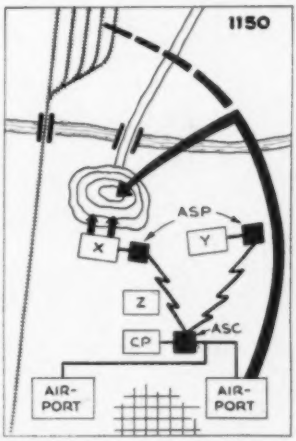
Fast fighters, such as this P-39 Bell Airacobra, serve as camera planes. Below, lenses of two K-17 cameras protrude from its belly, slanted for overlapping composite photos

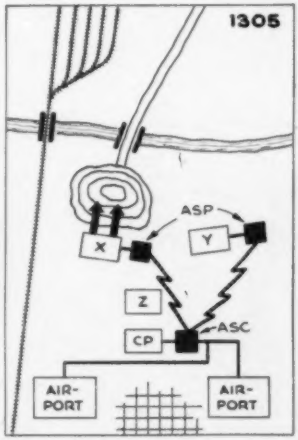
A quick decision is made: the tanks must come first. A reserve squadron of B-25's is ordered to smash the enemy armored column

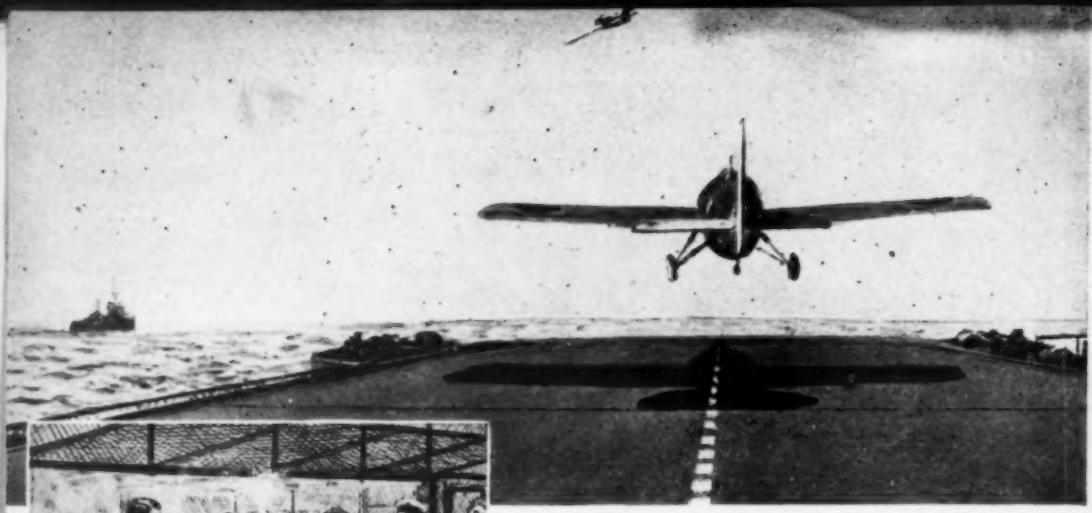
By radio, a squadron of bombers is diverted from a mission to bomb an enemy rail yard and "vectored" to help out the hard-pressed infantry

After bombs have silenced the defending guns, combat team "X" is able to storm the hill and sweep on toward the river crossing beyond









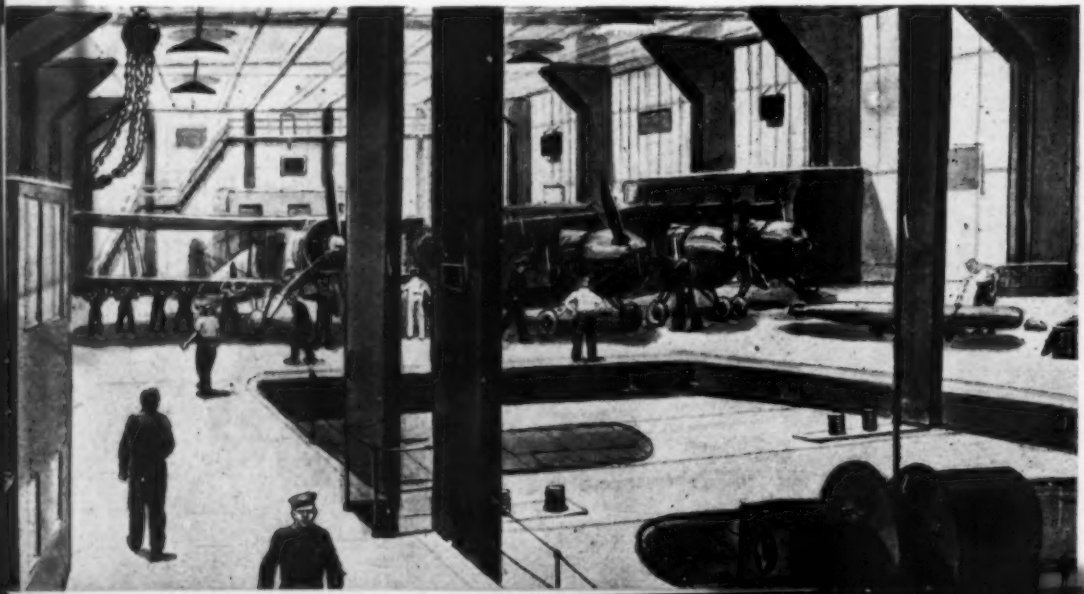
KNOCKING OUT

BABY FLAT-TOPS PACK PUNCH

Planes based on tiny carriers spot and kill U-boats before they even see our convoys. One of these flat-tops, converted by U. S. shipyards from cargo vessels and called "Woolworth carriers" by the British, is pictured here by G. M. Davis, artist for the Illustrated London News.

Mealtime aboard the converted carriers is welcomed by British as well as U. S. crews. The British like the cafeteria arrangement, calling it typically American. The crew's quarters are roomy, for a fighting vessel

This is one of the first views of the hangar of an escort carrier. The elevator mechanism is shown in the right foreground, while the elevator is raised. Wings are being extended on the plane at the left

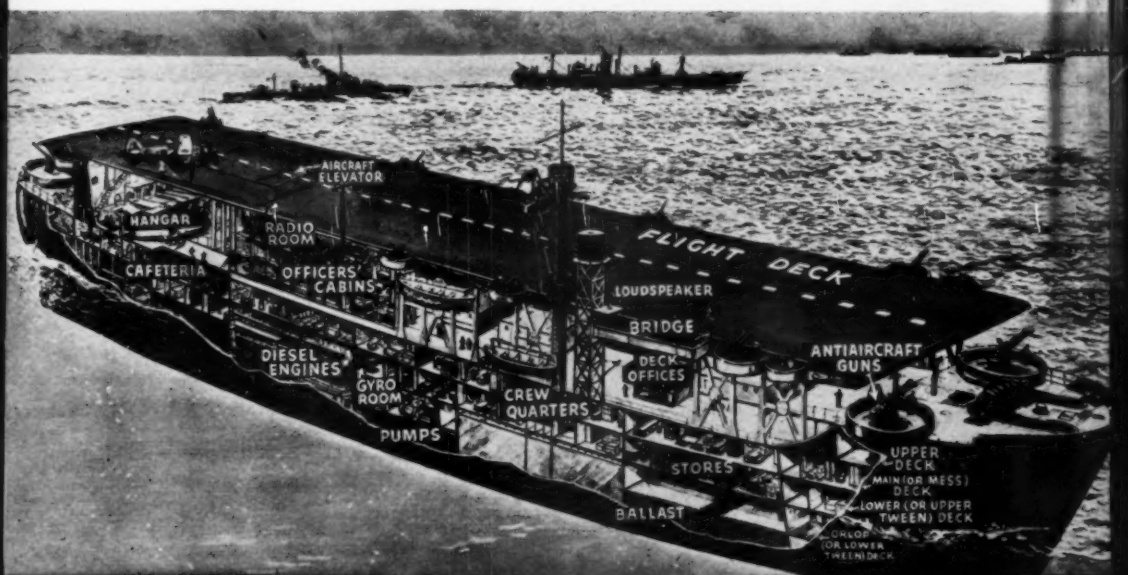


Rising from the deck of a baby flat-top, the plane at left takes part in the daily hunt for wolf-pack submarines. Aircraft from such vest-pocket carriers as this, converted in U. S. yards from 17,000-ton motorships and used by both the British and Americans, are keeping the Atlantic seaway open for valuable war shipments

THE U-BOAT

All flying as well as navigation orders come from the bridge, situated outboard on the starboard side. The officer at the extreme right is in control of the take-offs and landings. Sometimes these are very tricky in a badly pitching sea

Funnels, unnecessary in the operation of a motorship, are removed so the flight deck can stretch across the entire top to provide a maximum runway. The location of the plane elevator, shown flush with the deck, and other parts of these baby flat-tops, is given in the drawing below

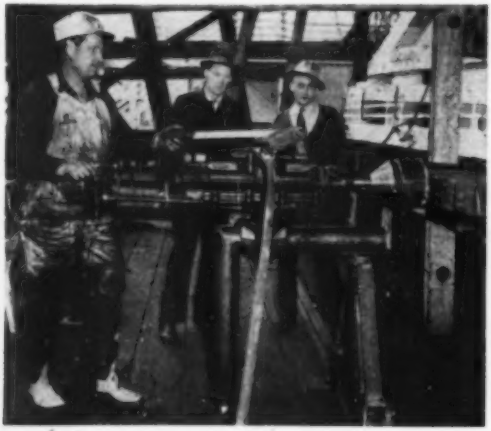


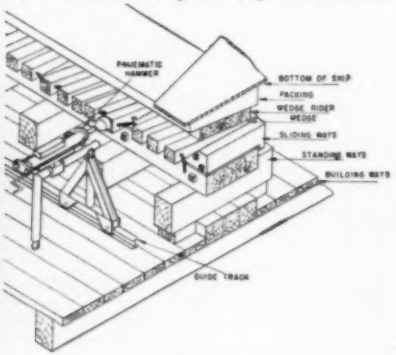
BUNA BOOTS, made to the specifications of regulation rubber boots, are among the latest products of the Government's synthetic-rubber program. Turned out in quantity on the production lines of the Connecticut plant of the United States Rubber Company for essential workers, they are made entirely of buna S and rubber cement.

SEEING FOR THE BLIND, an "electric eye" guards sightless sewing-machine operators by applying a brake when fingers near the needle. Developed by J. O. Kleber and M. G. Gregory, of the American Foundation for the Blind, it also signals a broken thread.

CAN OPENERS with a blade that folds flat are being furnished U. S. soldiers for use on tinned rations. The opener weighs a fifth of an ounce and fits on a key ring.

MECHANIZED LAUNCHING has replaced brawn at the Kaiser shipyards and cut man-hours on the job by two thirds. An air ram on rails now hammers in wedges at the rate of 11 a minute to lift the cradle and shift the weight of a completed ship from keel-blocks to sliding ways. Eight rams, each handled by three men, are required to drive the 1,000 wedges used in launching a Liberty ship. The ram is the invention of Fred Schlotfeldt and Kenneth Hunter, Vancouver yard superintendents.





With a watch and two charts you can find your position anywhere in the world.

Aided by the brightly shining stars, these three men on a raft could be in the middle of the Pacific and still have a good chance of reaching the safety of shore. Currents, winds, clouds, reflections, birds, and sea life will help if they know how to read their meaning

How to Navigate a Raft

ANCIENT ART OF THE POLYNESIANS IS REDISCOVERED TO AID SEAMEN AND FLYERS ADRIFT FAR FROM LAND

By SEYMOUR FREIDIN

SUPPOSE you got tossed out on the ocean from a torpedoed ship or a plane that couldn't make it home after a bombing raid. Do you think you could find your way to land? You stand a good chance of doing just that if you have with you on your raft a watch in a waterproof case (or, better still, in a transparent, waterproof rubber sack that can be kept closed) and two charts, one of the heavens and one a navigational base chart of the world, and both drawn to the same scale.

Even without these basic implements, Polynesian travelers of some 600 years ago made long voyages over the trackless Pacific —the last of them a great colonization trip from Tahiti to New Zealand, a distance of 2,500 miles. Their navigators used simply their eyes, their sense of hearing and of smell, and a primitive knowledge of the heavens and the sea.

But their method of navigation has been buried these past six centuries in a maze of Polynesian song and legend—known only to their priests and wise men and transmitted by word of mouth from generation to generation since economic necessity and tribal differences no longer prompted these great sea

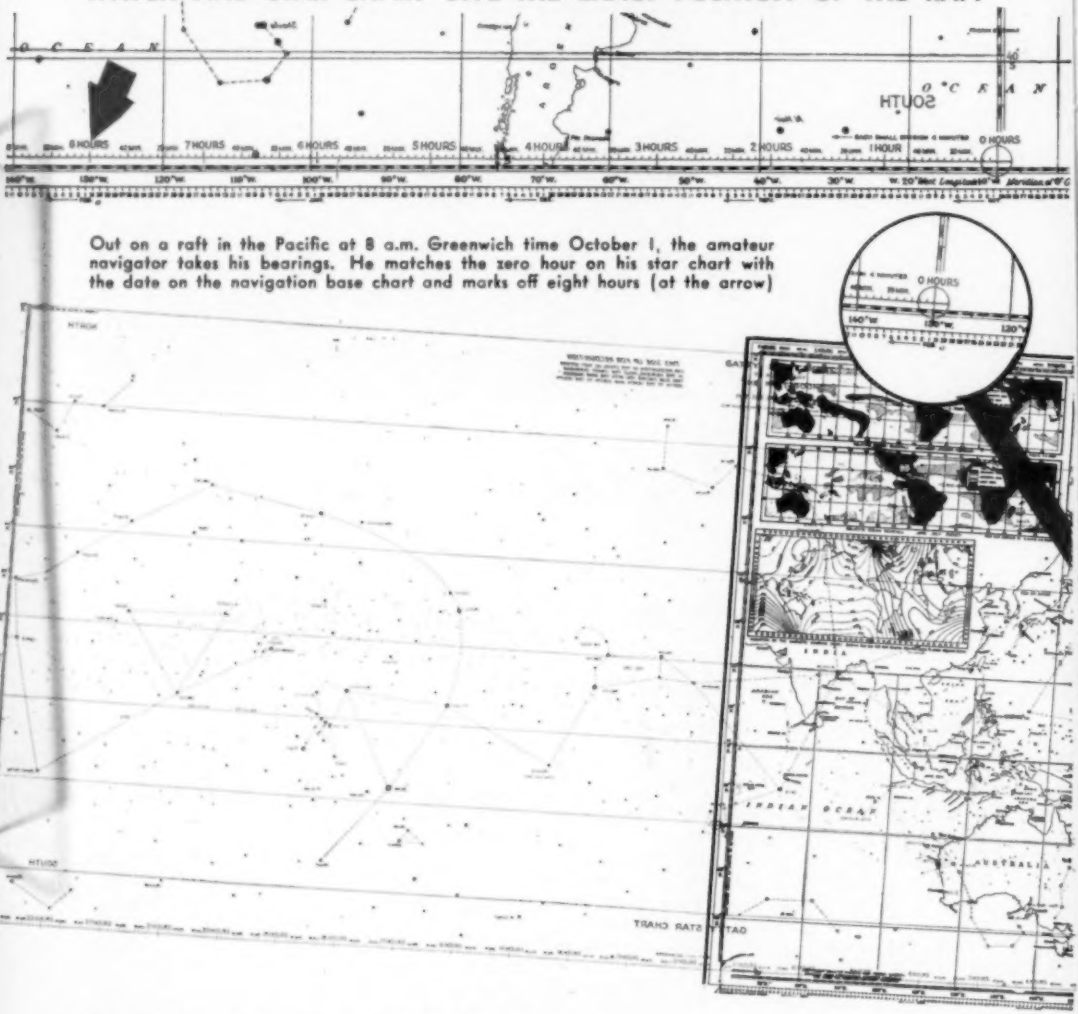
migrations. Their secret has only recently come to light, and it is so remarkably simple that a system based on it opens the prospects of successful navigation to the most absolute landlubber.

Capt. Harold Gatty, who was Wiley Post's navigator on his first round-the-world flight and has passed most of his life in the South Pacific, has written "The Raft Book" (the George Grady Press, New York) based on extensive research in Polynesian legend. "The Raft Book" is intended as a guide for those lost anywhere on the world's oceans. Through the courtesy of Captain Gatty, POPULAR SCIENCE is able to present here some of its more important features.

What value there is in following the stars, what various types of sea birds and fish indicate, how currents and winds may be used to advantage, what aid can be had from clouds and reflections in the sky—a knowledge of these things helped the Polynesians reach their destinations, and they will help the average man today as well, even if he is without training in navigation.

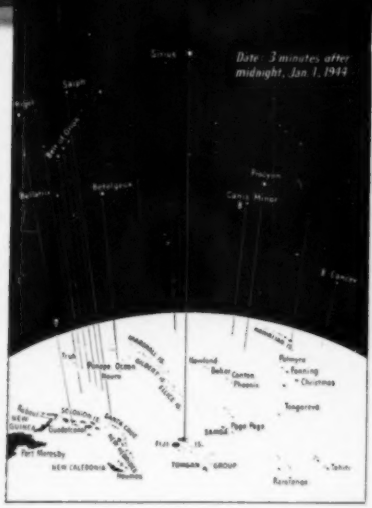
With neither charts nor watch, the Polynesians relied on a traditional lore of the stars, viewing them as moving bands of

WATCH AND STAR CHART GIVE THE EXACT POSITION OF THE RAFT

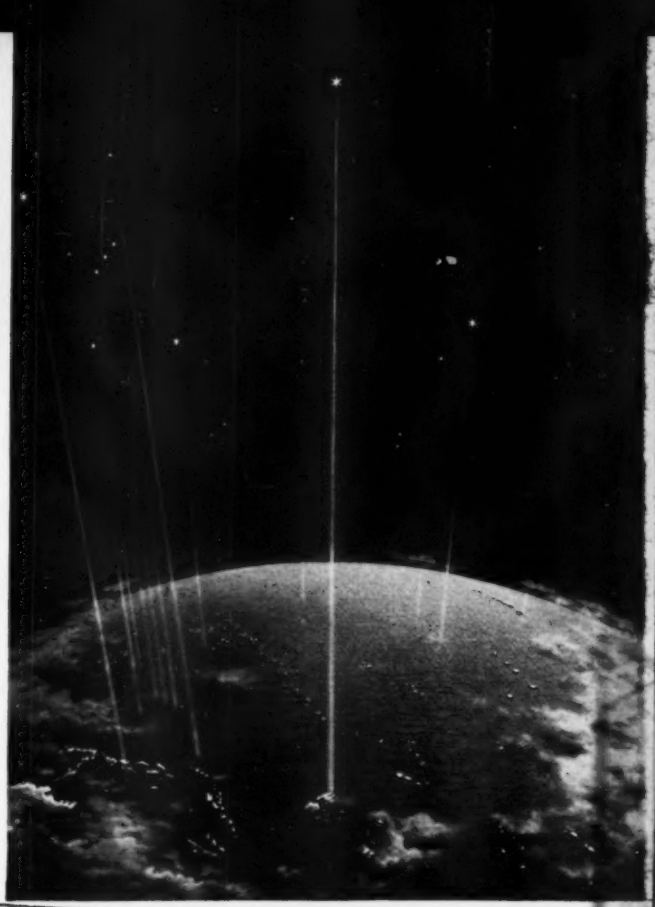


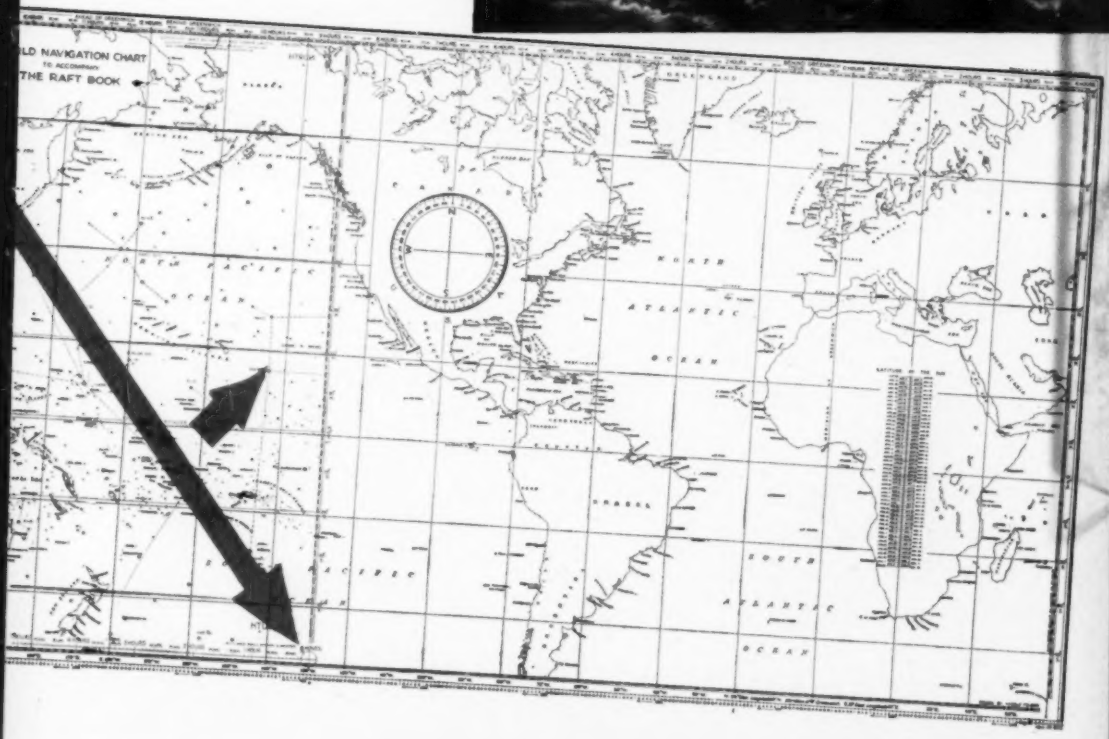
Out on a raft in the Pacific at 8 a.m. Greenwich time October 1, the amateur navigator takes his bearings. He matches the zero hour on his star chart with the date on the navigation base chart and marks off eight hours (at the arrow)

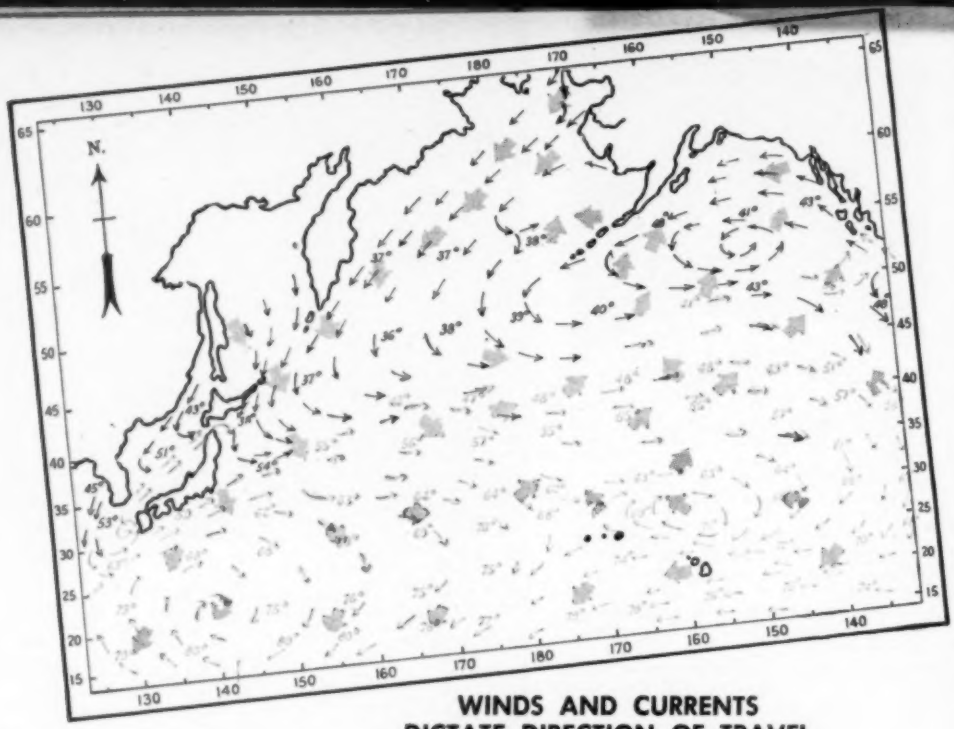
Moving the zero to the new point and identifying the star above him as Markab, he spots his position on the base chart and finds he is east of Hawaii. The star chart is looked at as from above



Stars were looked upon by the Polynesian navigators of six centuries ago as moving bands of light that passed over the same islands night after night. Those passing over particular islands were memorized and used as beacons to lead the Polynesians to their destination. At right and in the diagram above, Sirius is an overhead star for Vanua Levu in the Fiji Islands at three minutes past midnight on January 1, 1944. All the stars are shown in their actual position for this moment. On each succeeding night they will appear in the same positions about four minutes earlier







WINDS AND CURRENTS DICTATE DIRECTION OF TRAVEL

=WIND

=WARM CURRENTS

=COLD CURRENTS

Next, the raft navigator turns to a chart of winds and currents in the area of the Hawaiian Islands and finds that if he uses a sail he may be blown far to the south, but that the current will carry him in. He can cast a sea anchor and drift with assurance

light. They knew all the stars of each band that passed over the islands in which they were interested, and knew what star would be over a given point at a given time. Then they simply set their course by this star. This required years of memorizing, however, and restricted the Polynesians to the stars passing over the islands with which their navigators were familiar.

Since stars and their positions in different seasons of the year cannot be memorized overnight, Captain Gatty simplifies this system of navigation by providing a chart of the stars with markings on the border in Greenwich time. If you are able to recognize a star overhead and identify it on the chart, it makes little difference whether you know its name.

One essential feature of Captain Gatty's star chart is that it is printed on transparent paper. Thus, with the stars visible from either side, the chart may be used both to check on the night sky and to find the position of given stars on the navigational base chart of the world. In checking on the stars overhead, the chart is looked at from one side; in locating them on the navigational chart, it is looked at from the other, as if you were yourself above the stars looking down on the ocean.

To complete the system of navigating by the stars, you must keep your watch running on Greenwich time or be able to make calculations from it in Greenwich time. This is necessary, since the transparent sheet is moved over the navigational chart in accordance with the time of day in Greenwich time and with the date.

Just as the Polynesians "chased the stars" to their destination, you can pick out a star on your course and follow it with equal assurance of success. The movement of your "guiding star" must be watched hourly, and your course set an increasing or decreasing amount to one side according to whether the star is moving away from your destination or toward it.

In weather when the stars are not discernible, there is a duration-of-the-day method of setting your course that will serve as well. This consists simply of measuring the length of time between sunrise and sunset, and using this knowledge along with the date to find latitude and longitude in hemisphere tables included on the navigational chart. Probably the only way to determine the duration of the day on a raft is the slow but sure one of taking readings from your watch at both sunrise and sunset.

Eyes and senses must also be brought to

bear to pick up and recognize signs that will help you guide your raft toward land. Use the winds and currents in propelling your craft, sailing if the wind is right, or using a sea anchor that will keep you drifting with the current. Before deciding which to try, however, decide whether the resultant winds—the sum total of the prevailing and the other winds—or the current will better serve you. You should know, too, that the winds may blow in one direction and the current may flow in one directly opposite. Captain Gatty has prepared winter and summer charts of the winds and both warm and cold currents covering all waters.

Birds can also be a big help in finding direction. The Polynesians saw land birds take off year after year in the same direction and knew that they could not rest on the ocean. In the great voyage to New Zealand, they followed the route of the long-tailed cuckoos after repeatedly observing the migration of these birds from Tahiti.

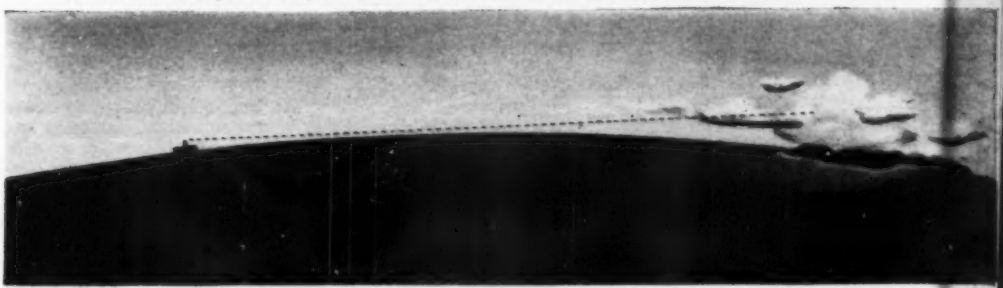
The Polynesians frequently carried frigate birds as an aid in sighting shore. Released, these birds would fly upward, spot land if any were to be seen, and go directly to it, or else, if land were not in sight, they would return to the boat, from which they could be set loose again later on. Pigeons could be used easily as substitutes.

Captain Gatty has prepared pictures of the main sea birds along with a list of their characteristic markings to help in identifying them. Noting their flight is one of the most important ways of telling when you are near land and in what direction it lies. The type found over any area of the ocean depends on the temperature, depth, and salinity, and the movement and kind of marine life present. Identifying the birds will often give additional information.

Most tropical sea birds do not range far from their breeding grounds on islands and coasts, and as a consequence they are not often seen far from land. All of them are edible, and they are easy to catch. You can bag an albatross or other hook-billed bird

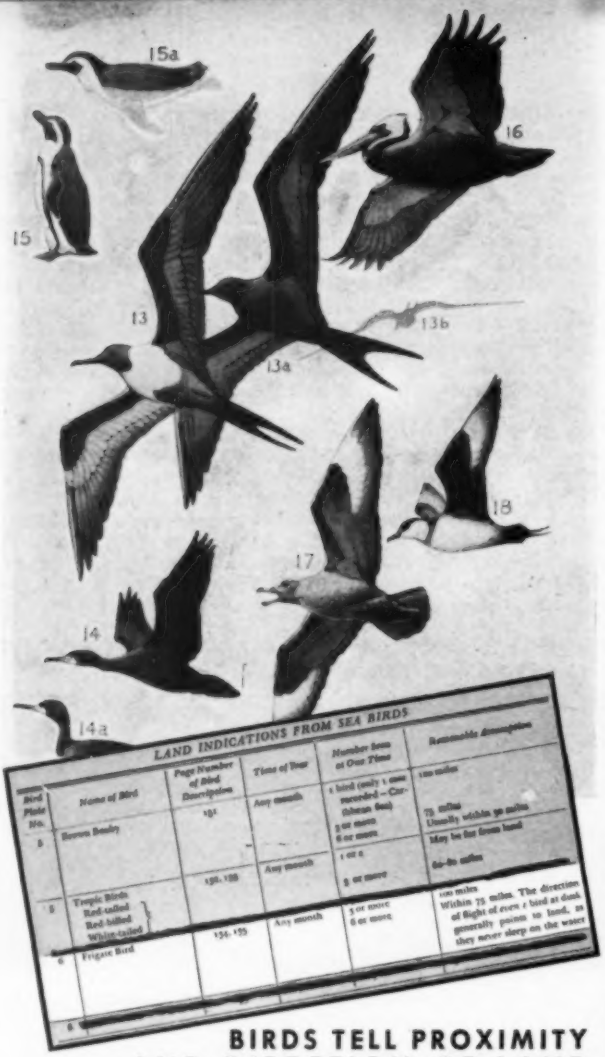
SMALL CLOUDS AND SWELLS DISCLOSE THE NEARNESS OF LAND

Note: In Captain Gatty's "The Raft Book," these illustrations appear in full color



↑ Because white sand reflects more heat than the sea, small clouds hover over all atolls

Parallel swells, curving to the shape of the land, are driven toward an island by the prevailing wind ↓



BIRDS TELL PROXIMITY AND DIRECTION OF LAND

Close watching of sea birds is a good guide to shore. These creatures cannot land on the ocean, and toward dusk they always fly back to the nesting grounds. Above are excerpts from Captain Gatty's book, giving pictures of sea birds and outlining their most helpful characteristics

with a shiny metal object tied to a string.

Keep a sharp lookout for fish and other surface life, bearing in mind that rich marine life occurs in quantity only relatively close to shore. Far out, there generally are whales, porpoises, large sunfish, and ocean bonitos.

Polynesian navigators watched the sky, knowing that small clouds hovered over atolls. This is because the white sands reflect more heat than the surface of the water and cause a difference of temperature above. The cloud over your atoll will be a little to the lee side, blown that way by the prevailing wind. You will be able to see on its underside a reflection of the bright turquoise lagoon long before the atoll appears over the horizon.

Deep water is a poor reflector, but lagoons and other shallow waters play their colors on a cloudless sky. In polar regions, this results in "water skies" and "ice blinks." The former, a sharply defined shadow in a bright sky, indicates open water in the midst of ice, and the latter, a patch of brightness in the gray, means floes or shore ice in open water.

Waves and swells tell their tale as well. The prevailing wind carries parallel swells toward an island, and they curve to the shape of the land as they near it. Those directly in front form waves that break on the reefs.

Sounds also can give you a good idea of how near shore may be. Gulls, with the exception of the kittiwake, are not found far out, and their cries in flight generally indicate near-by land. In fact, continued cries of sea birds from one direction usually signify a roosting place on the shore. There are such sounds, too, as breaking waves, fog whistles, and buoys. And, of course, if you hear a factory or train whistle, it's all over but the celebration.

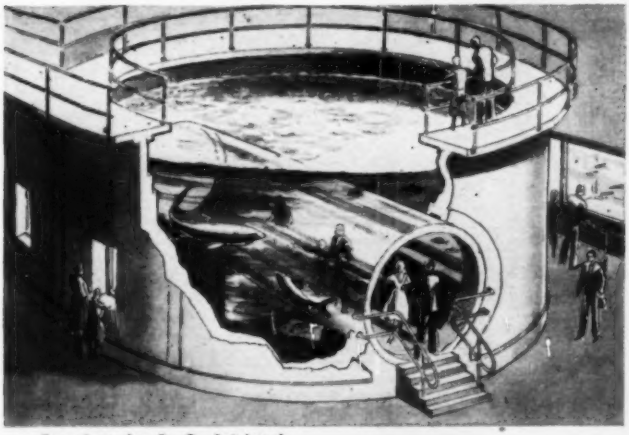
But don't try to go head on into the shore when you actually sight it. It's usually dangerous to attempt a landing from the windward side of an island, and even on the lee side, heavy surf may make it hazardous. Don't risk everything by trying to fight your way in. If you have any doubts, remain outside the breakers and signal for help with any means at your disposal—a pistol shot, a flare, a distress flag, or a plain, lusty shout.

Navigating the high seas in a small boat is perfectly possible if you know how. The Polynesians did it—and so can you.

CONEY ISLAND AQUARIUM TO BE WORLD'S LARGEST

THE largest aquarium in the world, to be built by New York City at an estimated cost of $1,500,000, has been tentatively planned for postwar construction at Coney Island. In addition to virtually every known type of fresh and salt-water fish, the aquarium will exhibit biological specimens and aquatic birds gathered from all parts of the world.

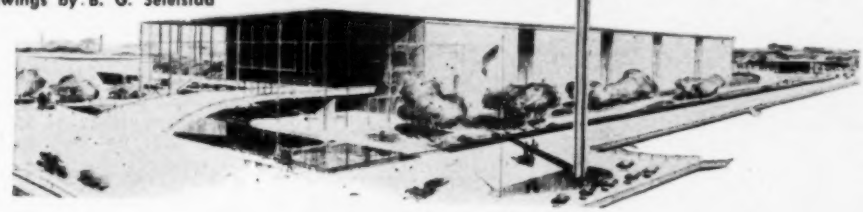
Covering a 10-acre area, the proposed aquarium will include a main building housing practically every fresh and salt-water fish known to man, outdoor pools for seals and penguins, and a special aquarium for children. There will also be restaurants, a lecture hall, and a promenade deck. The above is our artist's conception of how the "oceanarium" will look



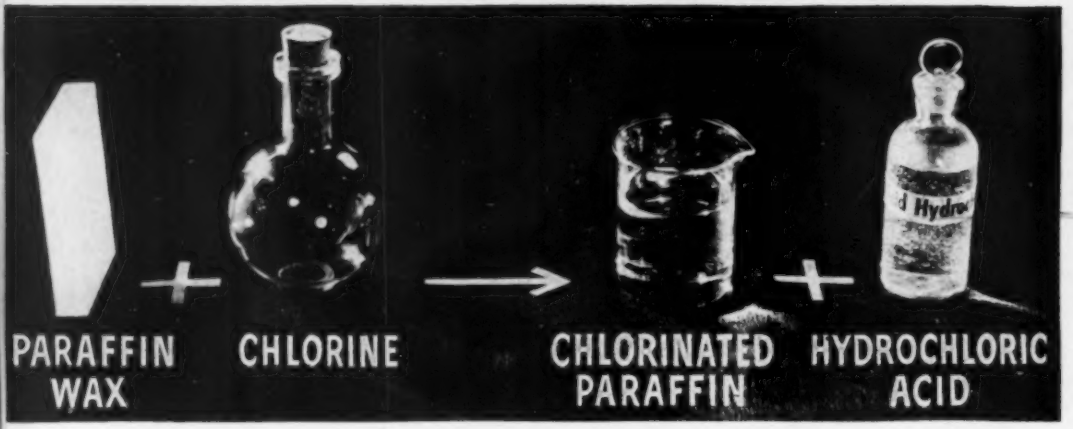
Among the interesting novelties proposed for the aquarium are glass-enclosed passageways through the giant tanks which will enable visitors to get unusual views of the fish. There will also be a catwalk at the top of each tank, and viewing windows in its sides

Drawings by B. G. Seielstad

Plans call for a special section in which waterfowl and aquatic birds will be housed



PARAFFIN PRODUCT FIREPROOFS, WATERPROOFS FABRICS

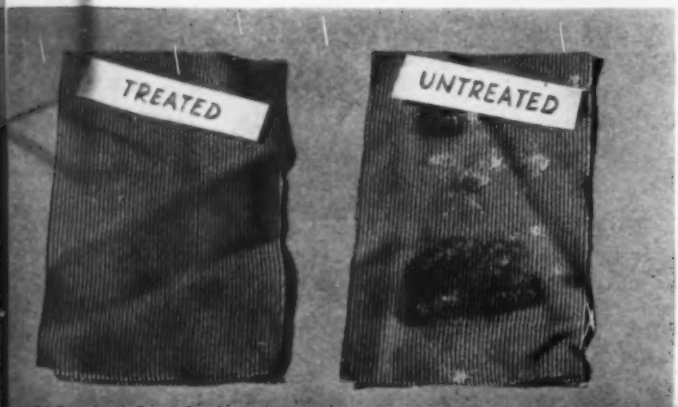


BY BUBBLING chlorine gas through melted paraffin wax so that the chlorine replaces the hydrogen in molecules of the paraffin, industrial chemists are now economically producing a noninflammable wax which, when applied to textiles, renders them waterproof, fire-resistant, and mildewproof. The hydrogen that is eliminated from the wax is then made to combine with excess chlorine and thus produce hydrochloric acid as a by-product. The odorless, durable wax can also be used in making plastics.

Shown above is the chemical sequence in which chlorine gas, bubbled through paraffin wax, produces chlorinated paraffin. The hydrogen that is eliminated from the paraffin is then combined with excess chlorine to produce hydrochloric acid

In a test of the wax's waterproofing qualities, as shown at far left, a treated piece of fabric resists water poured over its surface, while an untreated piece of the same fabric allows the water to pass through it into the receptacle

At the immediate left, ordinary paraffin is shown burning steadily after having been ignited, while the chlorine-treated paraffin remains unaffected when it is placed over a match



The third protection that the new wax affords textiles is to render them mildewproof. These pictures show the difference in the reaction of two pieces of the same material—one treated, the other untreated—after prolonged exposure to dampness

WHEN RUSSIA FIGHTS JAPAN

A distinguished war correspondent forecasts a colossal conflict in the Far East—with the Japs the losers.

Tough, well-trained troops like these will meet the Japs in the Battle of Siberia. Antitank gunners, clad in white for camouflage against snow, drag their ski-shod piece into position for point-blank fire. The Red Army's antitank tactics stopped the Nazi panzers—and will stop the Japs

By WALTER KERR*

DISTANT Siberia may become one of the great battlefields of this war.

For years now, a defiant Russian army has glared southward across the Amur River into Manchukuo, where the treacherous Japanese maintain their powerful Kwantung Army.

Two strong forces poised to strike. Two traditional enemies. Mutual distrust. Mutual hatred. A conflict of interests that goes back more than 50 years.

When that war comes—and the people of Moscow told me it was inevitable—the world will find out that the Russians never took their eyes off the Japanese, even during the most critical days of the battles for Moscow and Stalingrad. They never weakened their Far Eastern force. On the contrary, they strengthened it, and they will continue to strengthen it as they continue to wage successful warfare against the Germans in the West.

The Battle of Siberia will be no side show, but a war with a million men and more on a side.

In the last two years, the situation in the Far East has changed considerably. In the beginning the Russians had their hands full with the Germans, and the only question was: Will the Japanese attack? Now the Russians are fighting a winning war with Germany, and the question is: Who will attack first, the Russians or the Japanese?

When I first got to Russia, Germany's mechanized army was driving on Moscow, and the people asked me: "Do you think the Japanese will stab us in the back?" But this year, following the successful Russian counteroffensive against the Germans west of Stalingrad, an official of the Russian Foreign Office told me: "You have been here long enough to know that when Hitler is beaten we will take on the Japanese."

The only question then is which country

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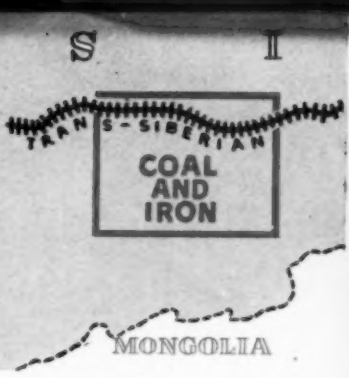
* *Reported crucial events of the war from Vienna, Prague, Berlin, Paris, London, and Moscow. Long service in Russia makes him an authority on conditions in that country.*

THE TRANS-SIBERIAN RAILWAY is Russia's life line to the "fronts" where her Siberian armies face their inveterate enemies across the Amur in Manchukuo. Traversing the iron and coal fields of the Kuznetsk Basin and the rye and wheat fields of the Irkutsk area, the double-track line would be a prime objective of a Japanese attack. Hedging against the loss of this vital rail link, the U.S.S.R. has built a second railway paralleling the Trans-Sib far to the north. This new line could be more easily defended and kept in service



will attack first. The answer provides the clue to the nature of the campaign that will be fought.

If Japan attacks, in a suicidal move of despair, we can expect the Russians to withdraw into the Siberian wasteland until they are strong enough to counterattack. But if Japan waits until Russia attacks, we shall see Russian troops driving deep into the heart of Manchukuo. For Russia will attack only when Russia is ready.

Russia this summer was already on a war footing in the Far East. Its divisions were not organized into military "regions," the customary peacetime designations that correspond to our "corps areas." "Regions" had been replaced by "fronts." We began to hear of the "Far Eastern Front" and the "Trans-Baikal Front." In Russia the "front" is a wartime organization headed by a front commander who directs the operations of several armies. In each of his armies he has a separate air force, one or more tank corps, and anywhere from five to 15 divisions.

Out in Siberia the "Far Eastern Front" embraced the eastern part of the Russian line, including the great port of Vladivostok. But Vladivostok is difficult to defend, so front headquarters was established farther to the north in the city of Khabarovsk. Here the commander was Army General Josef Apanasenko, a little Cossack called "Hercules" by his friends.

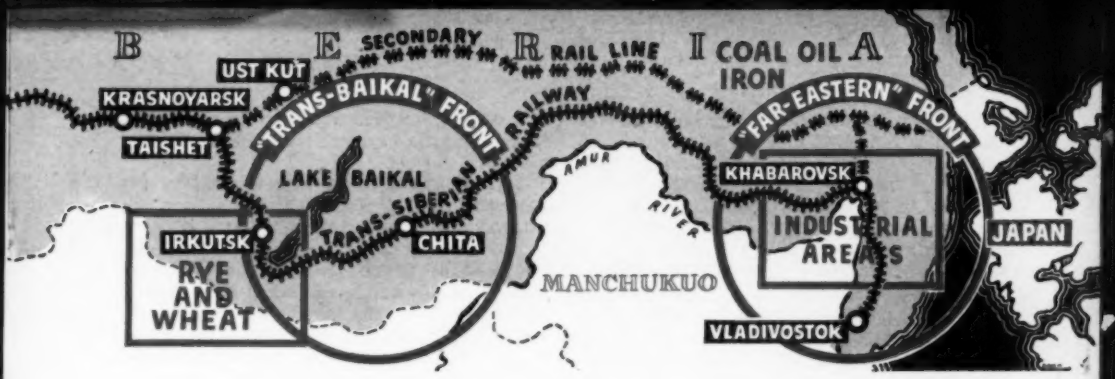
The "Trans-Baikal Front" was farther to the west—based, as its name implies, just east of Lake Baikal in the city of Chita. Its commander was Colonel General Georgi Kovalev, a big fellow with many years of service in Siberia.

If Japan attacked before Russia was ready in the Far East, Apanasenko would have to fight to defend the Trans-Siberian Railway, Vladivostok, and the new industrial areas that Russia built some years ago to supply its Far Eastern force. Kovalev would have to help Apanasenko by hammering at the Japanese flank, but his great mission would be to take a position astride the railway and prevent the Japanese from pushing along it to the west, toward the rye and wheat fields around Irkutsk and the coal and iron area of the Kuznetsk Basin beyond Krasnoyarsk.

The Japanese might be able to seize Vladivostok in a quick lunge from Manchukuo, and they probably could cut the Trans-Siberian Railway in a number of places. But the gains would be costly and would

"KATUSHA" is one of the surprises in store for the Japanese. An invention of Andre Kostikov, it is kept under wraps except at the front. Best guess is that it is an antipersonnel rocket gun that kills with a spreading flame. At right is a variation of it

CAVALRY will have its innings on the Siberian plains. The Red Army uses mounted troops effectively in masses of two or more divisions. Horsemen of friendly Outer Mongolia will help give superiority



lead to nothing. For the Russians have already moved their Pacific fleet from the waters around Vladivostok, and they have built a new railroad paralleling the Trans-Sib many miles to the north. This line, which can be presumed to be in operation, runs from Ust Kut, just northwest of Lake Baikal, across the tundra regions to Komsomolsk, north to Khabarovsk.

Let's go back and see why the Russians have made these preparations for war, why every soldier and civilian I met in 18 months in Russia hated the Japanese the way Americans have hated them since Pearl Harbor, why they feel that war between the two countries is inevitable and that the only question is which country will attack first.

We can begin with February 9, 1904, when the Japs, striking as suddenly and as treacherously as they did at Pearl Harbor, attacked the Russian naval base at Port Arthur, precipitating the Russo-Japanese War which ended in disaster for Russia. The people of Moscow have never forgotten that cold February day, nor have they forgiven. By the terms of the Treaty of Portsmouth the Japanese not only took Port Arthur but obtained a free hand in Korea and took possession of the southern half of the Russian island of Sakhalin, lying north of Japan.

Then, after the Russian revolution of 1917, the Japanese joined the Americans and the British in a temporary occupation of parts of eastern Siberia. We pulled out in 1920, but the Japanese stayed on until 1922, and then they refused to surrender the northern half of Sakhalin. Finally, in 1925 the Russians forced them to withdraw. Diplomatic relations were opened between the two countries.

Nothing much happened then until 1931, when the struggle for supremacy in the Far East came out into the open. The Japanese occupied Manchuria, which they renamed Manchukuo. Russia fought back by aiding the Chinese. Japan forced Russia to sell its interest in the Chinese Eastern Railway that crosses Manchukuo, the short cut to Vladivostok.

Then the aggressive Japanese cast covetous eyes on Outer Mongolia, but the Russians said "No." That country, they declared, was Russia's sphere of influence. Stalin said he would go to war to prevent Japanese penetration. Border incidents developed. The Japs began testing Russian strength. In 1938 they tried to take a piece of territory near Lake Khassan on the border south

Russia's first line of defense against the Japs in Manchukuo is a gunboat flotilla on the Amur River. Bottom: Soviet infantrymen armed with Degtyarev 7.62-mm. submachine guns ride a 26-ton medium tank

The Red air force has proved its mettle against the Luftwaffe. These are YAK-1 light fighter planes, good on rough advanced airfields. Mongolian types, below, are common among Soviet Far Eastern troops

of Vladivostok. The Red Army kicked them back in a battle that involved the use of tanks and planes as well as infantry and artillery. The Japs tried again the following year to move into Outer Mongolia. In one great battle that lasted only a week, the Red Army surrounded and annihilated the Japanese Sixth Army. Marshal Georgi Zhukov, who won the battles for Moscow and Stalingrad, commanded the victorious Russian force. After that the Japanese pulled in their horns. But by that time every Russian knew that only war could settle the conflict of interests between the two countries.

Now for the weapons the Russians would use in a war with Japan—weapons tried and found excellent in the war against Germany. The Japs would find the Russians among the best artillerymen in the world. Russian divisions are liberally equipped with 45-millimeter (1.8-inch), 76.2-millimeter (three-inch) and 122-millimeter guns. They use them boldly, up forward with the infantry. A great number of artillery regiments are reserved for use by the high command, enabling it to organize mass fire on the sectors it selects for attack.

Russian tanks manned by experienced crews will include the heavy 42-ton KV model and the medium 26-ton T-34, both armed with three-inch guns.

Siberia is good country for cavalry warfare, and the Russians, aided by the Outer Mongolians, with whom they have a pact of mutual assistance—should have clear superiority in this branch. The Moscow conception of the best way to use cavalry is to employ it in mass, in units of two, three, or more divisions.

No American knows much about the Russian air force, but it has been able to keep pace with the German Luftwaffe, so its fighter planes, such as the MIG-3, the YAK, and the LAGG, should be able to handle anything the Japanese can send up.

As for the Red Army infantry, it probably has few equals in the world. Its men are tough, trained to endure hardships, accustomed to the climate, disciplined, and good marksmen. The experience of the war against Germany shows they are not afraid to die. Rifle divisions are thoroughly trained for antitank warfare, and the Japanese are sure to find their armored columns cannot succeed where Germany's armored divisions could not. Every unit has its antitank detachment, and the troops are trained to use antitank rifles, fuel bottles ("Molotov cocktails"), and heavy antitank grenades.

Furthermore, the Red Army has a few cards up its sleeve which the Japanese know nothing about. One is a weapon that the soldiers call "Katusha," probably some sort of a rocket gun that kills with a spreading flame. Russians say it won the battle for Moscow.

Back of the fighting forces is a new industry in the Far East, which has been developed since the revolution of 1917. North of Khabarovsk and Komsomolsk are coal, iron, and oil fields. Most of the oil comes from Sakhalin and is refined in Khabarovsk and farther to the north at Nikolaevsk. There are great cement plants at Vladivostok and Komsomolsk, and three steel plants producing everything from pig iron to rolled-steel products at Petrovsk-Zabaikalsk near Chita, at Komsomolsk (a new shipbuilding and metallurgical center), and at Irkutsk.

The armies of the "Far Eastern Front" and the "Trans-Baikal Front," equipped with excellent weapons and backed by a recently developed industry and an improved transportation system, will employ tactics developed during the war with Germany. There is nothing much about them that was not known to military science before the war, but through trial and error, defeat and victory, the Russians have found out the best ways to use their available manpower and equipment. They have learned to fight on a wide front, employing mobile striking forces to smash enemy attacks and to obtain superiority in the sectors selected for offensive action. In the early days of their war with Germany, they were a little inclined to slug it out with the enemy, regardless of the enemy's strength. Now they have learned to fall back rapidly and then to strike in counteroffensive at the proper moment. They have also learned a great deal about communications and supply.

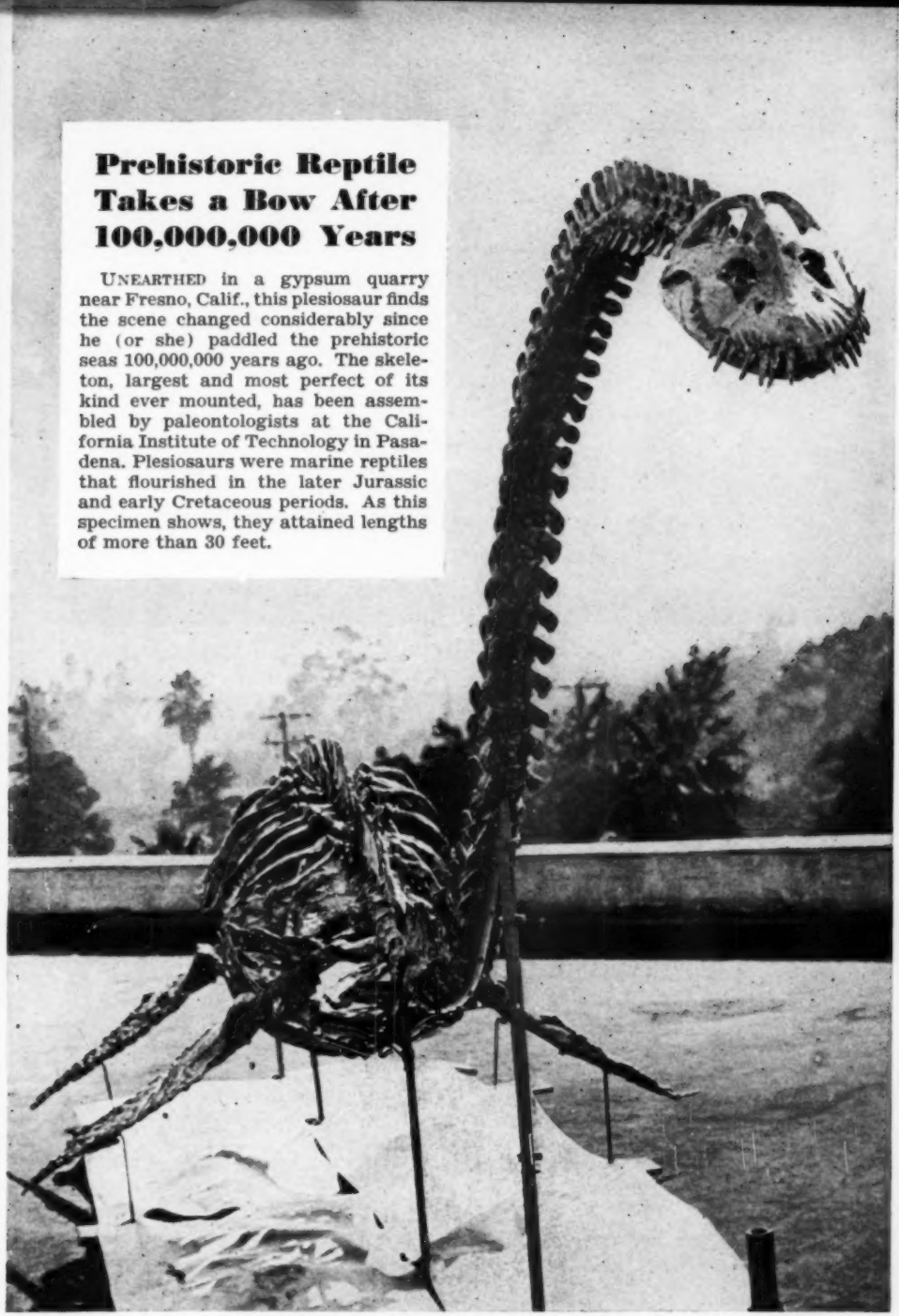
The Japanese have had a healthy respect for Russian arms ever since they clashed with the Red Army at Lake Khassan in 1938 and at Khalkin-Gol in Outer Mongolia in 1939. That, undoubtedly, is why they never dared to cross the Siberian border in the first two years of the German war, although the Nazis in Berlin must have called upon Tokyo for help.

As time goes on, as the Germans continue to take a beating in the West, Russia will get tougher in the East—not, I am sure, to help America, Great Britain, and China in their war with Japan, but to settle old scores that go back to that February day in 1904, when the Japanese jumped the Russian fleet.

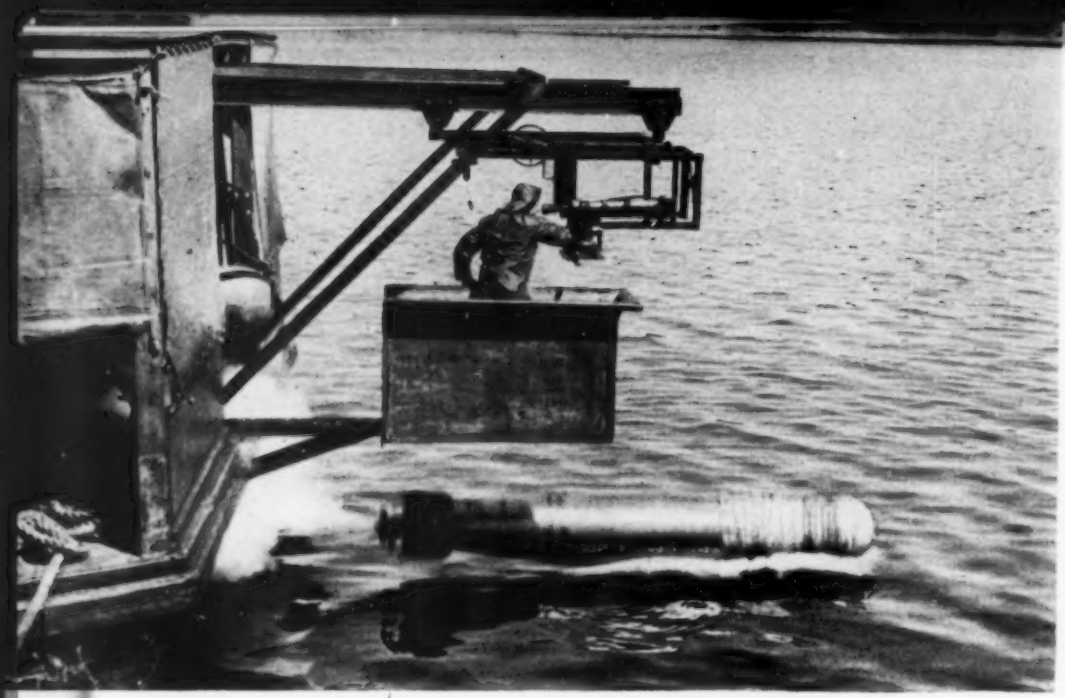
Whichever country is first to attack, the ultimate outcome is clear. Japan will go down in defeat. Its cities will be bombed from Russian soil, undoubtedly with American planes. Its Kwantung Army will be driven from Manchukuo and almost certainly from Korea. Siberia will be a battlefield, and perhaps the graveyard of Japanese treachery and aggression.

Prehistoric Reptile Takes a Bow After 100,000,000 Years

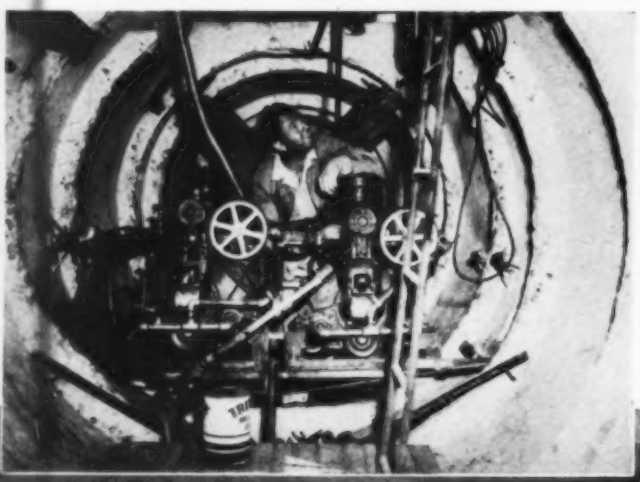
UNEARTHED in a gypsum quarry near Fresno, Calif., this plesiosaur finds the scene changed considerably since he (or she) paddled the prehistoric seas 100,000,000 years ago. The skeleton, largest and most perfect of its kind ever mounted, has been assembled by paleontologists at the California Institute of Technology in Pasadena. Plesiosaurs were marine reptiles that flourished in the later Jurassic and early Cretaceous periods. As this specimen shows, they attained lengths of more than 30 feet.



This is the largest and most perfect plesiosaur skeleton ever mounted. Assembled by paleontologists at California Tech, it shows the small head, long neck, and paddle legs of this genus of marine reptiles, which lived before mammals dominated the earth



TESTING TORPEDOES of the type carried by aircraft is simplified by a launching device used at the Naval Torpedo Station at Keyport, Wash. Constructed from salvaged metal by mechanics at the Keyport station, the device simulates the action of a low-flying torpedo plane in dropping its "tin fish" in the water near an enemy warship. From a boxlike platform suspended above the water, an observer watches the performance of the torpedo as it plows its way toward its target.



CONCRETE "SUBMARINES"—eel-like craft that will operate almost completely submerged as carriers of troops and cargo through waters infested by real underwater raiders, are envisioned by Hal B. Hayes and Hal Williams, both of Hollywood, Calif. At the left, Hayes is seen inside a 124-foot model, which is shown below under test on San Francisco Bay. If trials are successful, plans call for construction of full-size, 10,000-ton vessels of this novel type. The photograph shows the two V-8 motors that drive the model.

"LONG TOM" AT THE FRONT. U. S. troops in action have had welcome support from the huge shells hurled by our 155-mm. long rifle. Here one of the American-designed big guns is creeping across a bad spot in a bomb-battered Sicilian mountain road, under the watchful eyes of engineer troops who have just cleared a path for it.

WOODEN BELLY TANKS are used by the Japanese to give extra fuel-carrying capacity to their planes. The two flimsy specimens shown at the left were found near the Munda airfield when that important New Georgia base was captured by the American forces. Apparently, the containers are made of molded plywood with some sort of gasolineproof lining—a poor job when compared with American aircraft fuel tanks designed for similar uses.

JEEP ON RAILS. Still another job for the Army's versatile quarter-ton is indicated by the picture below, which shows officers trying it out in the new role of switch engine somewhere in Australia. Fitted with flanged steel wheels, the jeep proves that it can move a long string of loaded freight cars. A dump trailer doubles as tender.

Hellcat Has the Zero's Number

SOMETHING that would "go upstairs faster"—that's what our Navy fighter pilots asked for. And they have it now, in a new Grumman plane that makes the lethal Wildcat look like a fireside tabby. First warplane to be based on combat experience in the Pacific, the F6F Hellcat was in quantity production before the first model flew.

While the Navy intends to let the Japs learn about the Hellcat the hard way, it is no secret that the new fighter has a wide margin over the Wildcat in speed, climb, guns, and armor. And, since the older plane chalked up a score of five to one against the fast but flimsy Zero, that's something.

The first full squadron of Hellcats was delivered to the Navy last December, and there were F6F's in the Marcus Island raid. They are going to the U. S. Marine Corps and the British Royal Navy, too.

LIFE LIGHTS, with which men who have to jump from a sinking ship at night can signal to rescue parties, are being manufactured by the Celanese Celluloid Corp., of New York. Made of Lumarith plastic, the lamp is equipped with a 30-inch lanyard at one end of which is a safety pin that is fastened to the life belt. At the other end is a clamp, by which the lamp can be attached to a seaman's clothing. The light is turned on by screwing tight the lamp's domed cap.

NONSKID SEA BOOTS with thick, cleated heels and traction soles are being made by the U. S. Rubber Company for the protection of submarine-crew members while they work on the slippery decks of their ships. The new waterproof boots are roomy enough for insoles and three pairs of wool socks.

They Cleared the Tracks for Victory!

The Iron Horse Saves the Day

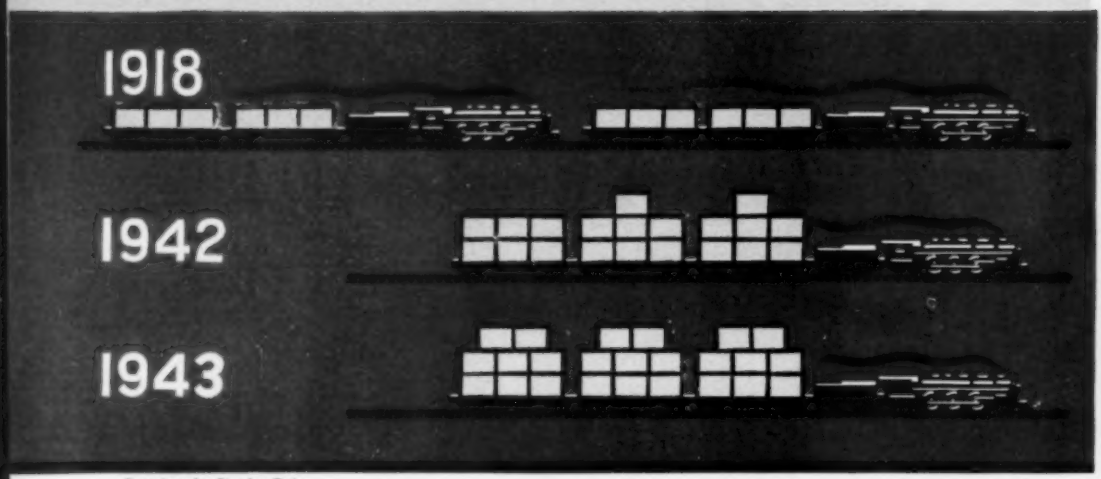
America started the war under the threat of a transportation crisis . . . but then the railroads came through with a miracle.

By HICKMAN POWELL

TALK all you want about airplanes and electronics and motor transport —the part of this war effort which really rates a shout of amazement is the role played by the American railroads. The iron horse, which plowed the plains and spanned the mountains, was not what he used to be. For the last 20 years he had been getting creaky at the joints. To this Buck Rogers generation, millions of whom had never even ridden on a train, it seemed that he was inevitably doomed to go out to pasture. But here is the old horse now, snorting in the traces, hauling bigger loads and faster than anyone dreamed possible—least of all the railroad men who are making him do it.

With fewer miles of road than they had in 1918, with fewer employees, with 20,000 fewer locomotives and 600,000 fewer freight cars, the railroads of America in 1942 moved two thirds more ton-miles of freight than in 1918, and in 1943 are moving twice as much. In the first three months of this year, their passenger traffic, which had slumped off to a trickle in the 1930's, was virtually double what it was in the corresponding period of 1918. And this, mind you, is the accomplishment of a transportation system which in 1918 was almost at its peak and for two decades after that had been taking it on the chin from the

Careful maintenance has kept old rolling stock up to par on the heavy-duty job of moving war materials



Drawings by Stanley Bate

With less trackage, fewer employees, and less rolling stock, American railroads in 1942 hauled about two thirds more ton-miles of freight than they did in 1918, and today are hauling almost twice as much

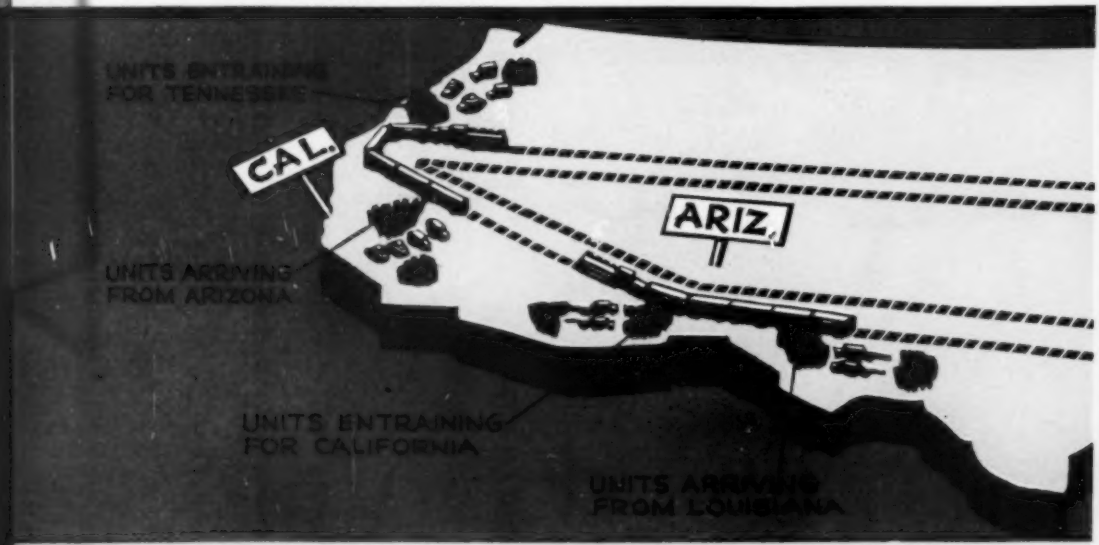
truck and bus competition of the motor age.

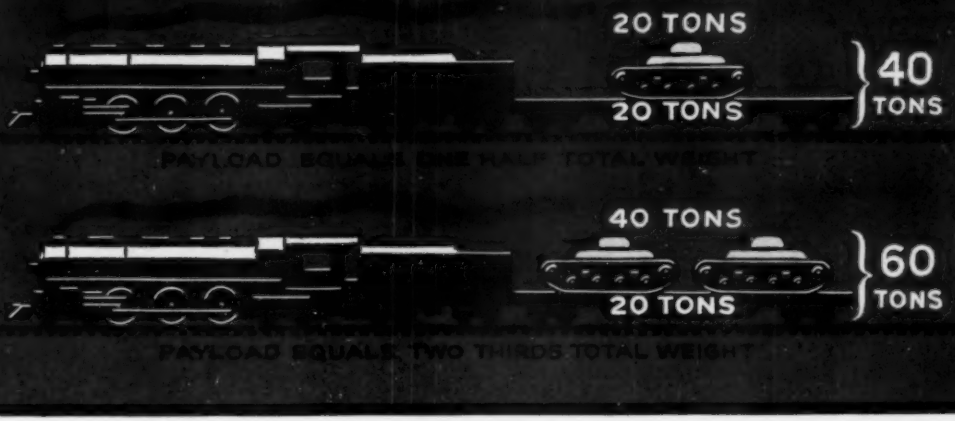
We Americans of the motor age, indeed, have only God and the railroads to thank for the fact that we avoided national disaster in 1942. Pearl Harbor was bad enough, but when the U-boat packs fell upon our defenseless oil tankers on the eastern seaboard, they were striking much closer to the actual vitals of the country. The whole industrial Northeast was dependent on gasoline, and the devastating success of the submarine was cutting off that supply.

It was the railroads that came to the rescue and averted the collapse of motor transport. A fleet of 70,000 old tank cars—used by the oil companies for odd jobs of storage and short hauling—were put to work, hitched into solid trains, and shuttled back and forth across the country on fast daily schedules as precise as passenger service. Railroad men had been laughed at when they first thought they might be able to move 200,000 barrels a day in this fashion, and soon it was proved how wrong they were. For by this last summer the old tank cars—stopping occasionally to get new wheels—were moving five times that much!

The East still starved for gas. But that was because the railroads had been so successful that the Army and Navy dared to

Farsighted management has also seen to it that cars don't sit around for days waiting to be unloaded, that they are kept in first-rate repair by the company on whose rails they happen to be rolling at the





One of the means by which the railroads have accomplished their miracle of transportation is by seeing to it that cars are loaded to capacity whenever possible. Above shows how this increases payload ratio

draw on eastern gas for their fighting supply.

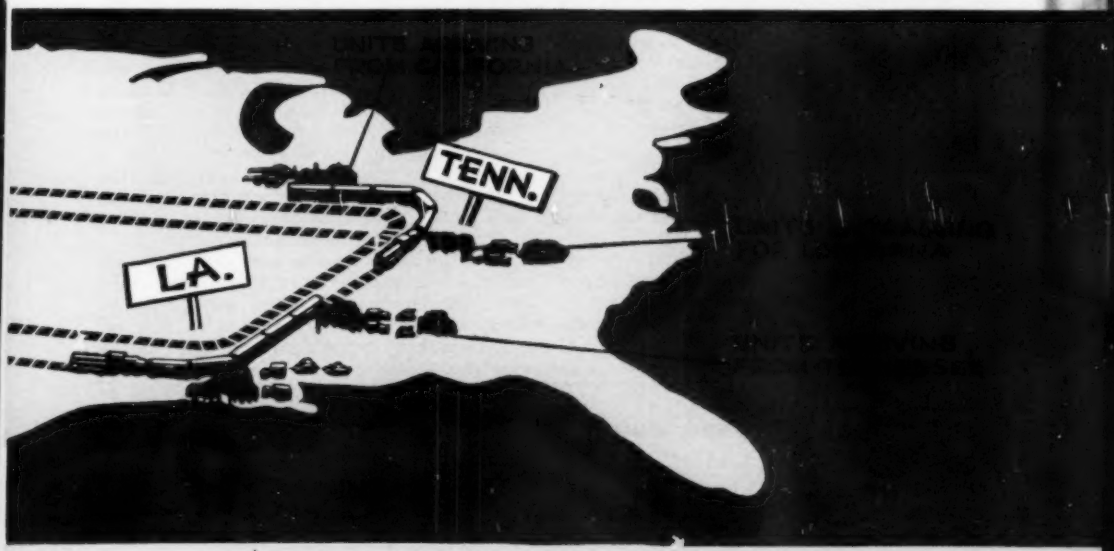
While this battle of oil was being won, the loss of Malay rubber to Japan threw another great burden on the rails. We have managed to get by on our tire supply, because railways have absorbed the great expansion of traffic that would have been on rubber.

Transportation is a fundamental necessity in any war. Sea transport, because it is under attack, and air transport, because it is new, have had the spotlight; but the railroads have handled a far heavier load, because they move each item many times.

From mine to smelter, to mill, to part factory, to assembly plant, our goods move from raw material to completion as engines of war, making each move by rail in a steady stream on which the flow of production is utterly dependent. Once assembled, the war machine goes to troops by rail, then moves with troops from training camp to maneuver area, back to training camp, and again to port of embarkation. Then, on its arrival abroad, the railroads resume the burden.

All the vast new factories, munitions depots, and training camps, springing up in sections where industry and population had been small, have been built and supplied with men and materials brought by rail. Freight traffic, which formerly moved pre-

moment, and that they never roll home empty. Typical of today's efficiency is the device, illustrated below, whereby cars moving troops are scheduled to receive a load as soon as they have discharged one



dominantly eastward through yards and terminals built to take it, now runs west in almost equal flow—to the great Pacific ports of embarkation, to the plane factories of California, to the shipyards of the Northwest. Why, for just one of Kaiser's Liberty ships, it takes a trainload of steel, which must arrive on time. And then the train returns, carrying copper or timber which ordinarily would have moved via the Panama Canal, now closed to merchant trade.

All this has gone on while trains rushed oil to the East; while millions of travelers, deprived of rubber, have rushed to the railroads; and while troop movements have reached a fantastic level. Where soldiers of 1918 moved perhaps three times by rail while training, today's troops move six to eight times, on trips averaging 800 miles, often spanning the continent. Transportation has been used prodigally, because the railroads could provide it. And the remarkable thing is that they provide it with almost no new equipment. Sidings have been lengthened to hold longer trains, intricate electric traffic controls have been installed to accommodate far more trains on a single track, yards have been built. But in general the rolling stock is little more than it was in quiet 1939. The new streamlined trains have kept running at full speed. The new 4,500-horsepower Diesels have hauled away unceasingly, dragging great loads across the western mountains. But a great part of the increase has been through the intensive use of equipment which had seemed almost ready for discard.

Intensive management has done the trick. For instance, it takes about 1,300 cars—passenger and freight—to move an armored division. A few years ago such equipment would have been immobilized for days or weeks after making a special run. But last spring, within a period of six weeks, one set of equipment moved seven divisions, on trips of several thousand miles.

First the trains, carrying troops with their tanks, moved one division from Fort Knox down to Camp Polk, in Louisiana. As each train unloaded, it picked up a unit from another division, bound for the Arizona desert area. From then on to California, back to the Tennessee maneuver area, again to Louisiana and the desert, and back to California and Tennessee. That series of movements, which could be accomplished only by careful advance planning and scheduling, is one of the prize accomplishments of the military transportation section of the Association of American Railroads, a civilian unit quartered in the Pentagon Building outside of Washington, where it functions virtually as a part of the Army, moving more than 2,500 special trains a month.

At one time during the First World War there were tied up in eastern terminals and yards more than 200,000 freight cars, far more than could be unloaded, while other parts of the country were suffering from car shortages. The job had been botched, so the Government took over the railroads and botched it some more. But all the fault was not on the railroads or the Government. Much of it was due to faulty planning by shippers.

The railroads and the Government both had more foresight this time. Locomotive power has been conserved by running longer trains, by keeping engines on the road for longer runs, and by loading cars more heavily. When a 20-ton car is loaded with 20 tons of freight, only half of what the engine pulls is payload. But load that car to capacity of 40 tons or more, and the locomotive is pulling twice as much freight while its total load is increased only by one half.

All purely military transportation—of troops, Army freight, and goods for Lend-Lease—is under direction of the Army Transportation Corps, set up after Pearl Harbor as a part of the Services of Supply, under command of Major General Charles P. Gross. In this country, the actual work is done by the roads themselves, co-operating under the leadership of their Association of American Railroads.

But once overseas, the Army takes control and its own railroad troops man the trains, in co-operation with our allies. Long before the war our railroad military units were set up as part of the Army reserves, entire skeleton outfits drawn from individual railways, with operating battalions modeled after the organization division, and shop and maintenance battalions.

On three rail systems across the north of Africa today American railroad men in uniform are working with a motley collection of French civilians, Algerians, and British soldiers, working with everything from the oldest of narrow-gauge engines to the newest of American cars and locomotives, uncrated and assembled on the spot. And as the African and Italian campaigns show, they have been getting results. Farther east, other American railway troops work in partnership with Persians, running the trans-Iranian Railway, from the Persian Gulf cross the mountains to Russia, moving the great flood of Lend-Lease supplies.

Over there they have new cars and new locomotives, thousands of them where they are needed most, and there will be plenty more when the troops move in on Europe. They are moving the stuff that will win the war; and whether or not they talk the same language, whether they are in uniform or not, they all understand each other on that. For they are all railroad men.

A flyer wearing the new A-14 rubber face mask used with the demand oxygen system. Around its edge the mask seats against the skin in an airtight seal

Something New in Fashions

With the new demand oxygen mask, our flyers challenge the Axis enemy at any altitude.

By STEWART ROUSE

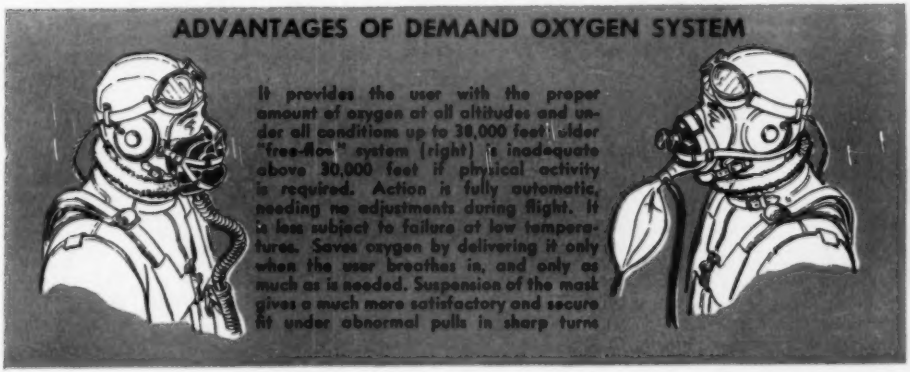
Drawings by the author. Photographs courtesy of U. S. Army Air Forces.

YEARS ago, our Army developed the first aerial oxygen equipment, along with its first high-altitude planes. This "free-flow" system worked well enough in the earlier days of military flying; the oxygen was fed from the regulator into the mask, and the pilot turned a handle to increase the flow as he gained altitude.

But in a modern warplane, under combat conditions, flyers have too much else to do. That's why the Aero-Medical Laboratory at Wright Field was set the task of designing oxygen equipment that would "do its own thinking." The solution they have come through with is a honey—the best oxygen system in the world, according to the Air Surgeon General, whose business it is to know.

It's called the "demand" system, because it automatically adjusts its flow to the demand of the flyer's body at any altitude. It gives him air without extra oxygen at ground levels. As he ascends into thinner atmosphere, it automatically begins to add oxygen to the air he breathes. And, it increases the proportion of oxygen as he goes up, until at 30,000 feet—when he needs it most—he's getting pure oxygen.

On night flight, simple adjustments vary the working of the demand system so that the flyer gets oxygen, in increasing quantities, all the way from the ground up. For, research has shown that lack of oxygen is a major cause of poor night vision. If oxygen

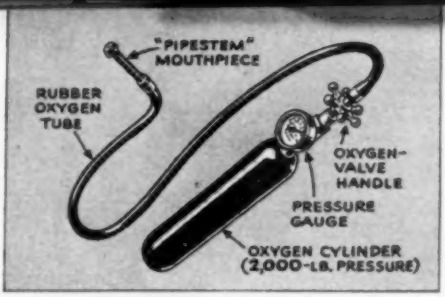

ADVANTAGES OF DEMAND OXYGEN SYSTEM
It provides the user with the proper amount of oxygen at all altitudes and under all conditions up to 38,000 feet. Older "free-flow" system (right) is inadequate above 30,000 feet if physical activity is required. Action is fully automatic, needing no adjustments during flight. It is less subject to failure at low temperatures. Saves oxygen by delivering it only when the user breathes in, and only as much as is needed. Suspension of the mask gives a much more satisfactory and secure fit under abnormal pulls in sharp turns

isn't used, night-vision efficiency drops with altitude. Effects are noted as low as 5,000 feet.

The "thinking" oxygen equipment looks complex but, in principle, it is relatively simple. The heart of the apparatus is the regulator, which gets its oxygen from specially designed, light but strong cylinders through a supply line or "trunk line." Air comes into the regulator through an air port which closes automatically at 30,000 feet. From the ground to 30,000 feet, the proportions of air and oxygen admitted to the automatic mixing regulator are controlled by a tiny aneroid bellows control, similar to that in a barometer, operating two valves. As the outside air pressure decreases with altitude, one of these valves opens the oxygen supply inlet farther and farther; the other closes the air inlet correspondingly.

One of the main drawbacks of the old-style equipment which the new regulator replaces was its tendency to waste oxygen. The older types supplied oxygen at all times. But the automatic regulator now incorporates a device which cuts off the oxygen flow every time the flyer exhales and renews it with each inhalation. This device, a little diaphragm working a valve, operates on the differential of pressure induced by the reversal of the flyer's breathing. When he breathes in, the diaphragm flips to one side and a little lever linkage opens the oxygen valve. But when he starts to exhale, the pressure moves the diaphragm and thus shuts off the oxygen-flow valve.

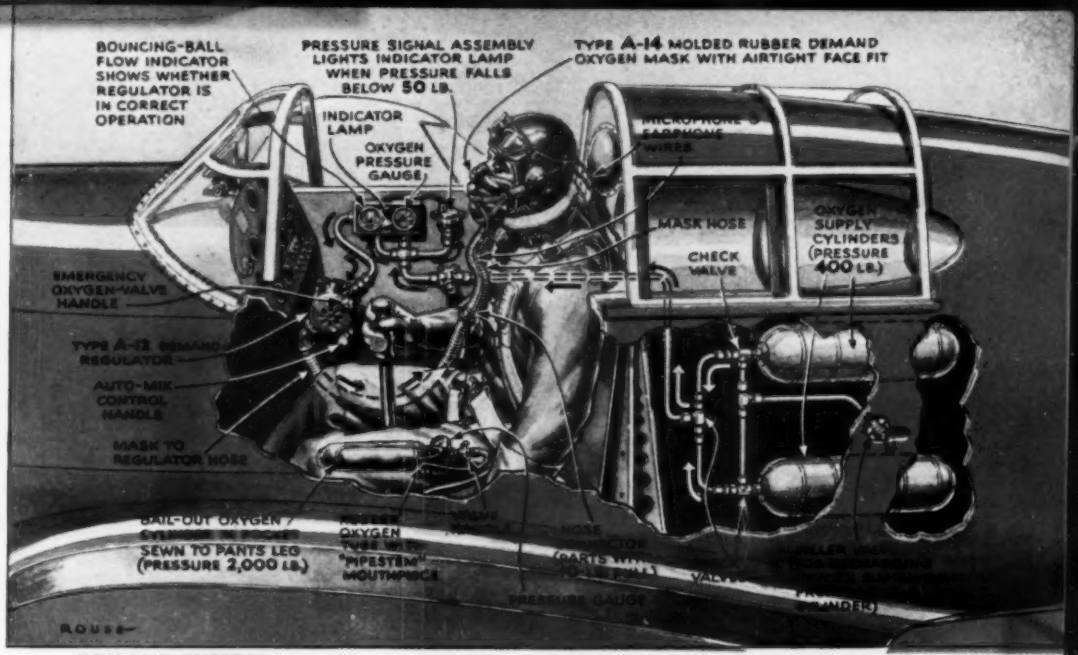
Sometimes, in flight, the pilot may want a momentary "shot" of oxygen. He gets this through a flip of the finger on the auto-mix button of the regulator. This cuts off the air flow when turned to the "off" position and thus gives pure oxygen at any altitude. If, for some reason, the mechanism should fail to function, there is another little handle labeled "Emergency"; this by-passes the entire regulator mechanism and causes pure oxygen to flow directly into the mask feed hose. *(Continued)*



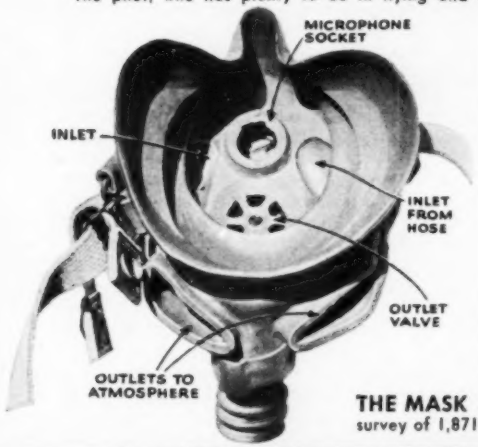
BAIL-OUT BOTTLE. If he has to jump, the airman discards his mask and sucks oxygen through a tube from a cylinder in a pocket of a trouser leg

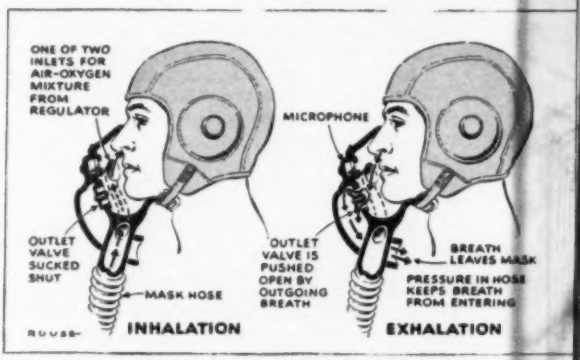
"WALK-AROUND" GIVES FLYER FREEDOM OF PLANE

To leave his station, a crew member in a bomber or cargo plane disconnects his mask hose from the demand-system regulator and plugs it into his walk-around. On returning to his station, he recharges the bottle as shown at the right. This operation is also illustrated in the Air Forces photograph on this month's cover


BOUNCING-BALL FLOW INDICATOR SHOWS WHETHER REGULATOR IS IN CORRECT OPERATION
PRESSURE SIGNAL ASSEMBLY LIGHTS INDICATOR LAMP WHEN PRESSURE FALLS BELOW 50 LB.
TYPE A-14 MOLDED RUBBER DEMAND OXYGEN MASK WITH AIRTIGHT FACE FIT
INDICATOR LAMP
OXYGEN PRESSURE GAUGE
MICROPHONE & EARPHONE WIRES
MASK HOSE
CHECK VALVE
OXYGEN SUPPLY CYLINDERS (PRESSURE 400 LB.)
EMERGENCY OXYGEN-VALVE HANDLE
TYPE A-12 DEMAND REGULATOR
AUTO-MIX CONTROL HANDLE
MASK TO REGULATOR HOSE
BAILOUT OXYGEN CYLINDER SOCKET SEWN TO PANTS LEG (PRESSURE 2,000 LB.)
OXYGEN TUBE WITH "PIPESTEM" MOUTHPIECE
ROUSE

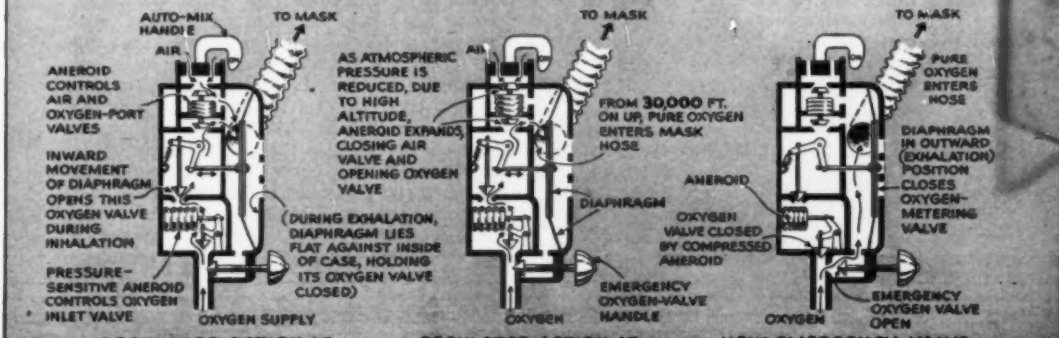
DEMAND SYSTEM is seen in detail in this drawing, which shows it installed in a fighter plane. The pilot, who has plenty to do in flying and fighting the plane, doesn't have to control his oxygen





THE MASK is a masterpiece of design, based on an anthropological survey of 1,871 aviation cadets (P. S. M., March '43, p. 96) to assure fit

REGULATOR IS HEART OF DEMAND OXYGEN SYSTEM


AUTO-MIX HANDLE
TO MASK
AIR
ANEROID CONTROLS AIR AND OXYGEN-PORT VALVES
INWARD MOVEMENT OF DIAPHRAGM OPENS THIS OXYGEN VALVE DURING INHALATION
PRESSURE-SENSITIVE ANEROID CONTROLS OXYGEN INLET VALVE
OXYGEN SUPPLY
(DURING EXHALATION, DIAPHRAGM LIES FLAT AGAINST INSIDE OF CASE, HOLDING ITS OXYGEN VALVE CLOSED)
REGULATOR ACTION AT 10,000 FT. DURING INHALATION
AS ATMOSPHERIC PRESSURE IS REDUCED, DUE TO HIGH ALTITUDE, ANEROID EXPANDS, CLOSING AIR VALVE AND OPENING OXYGEN VALVE
FROM 30,000 FT. ON UP, PURE OXYGEN ENTERS MASK HOSE
DIAPHRAGM
EMERGENCY OXYGEN-VALVE HANDLE
OXYGEN
REGULATOR ACTION AT 30,000 FT. DURING INHALATION
ANEROID
OXYGEN VALVE CLOSED BY COMPRESSED ANEROID
PURE OXYGEN ENTERS HOSE
DIAPHRAGM IN OUTWARD (EXHALATION) POSITION CLOSES OXYGEN-METERING VALVE
EMERGENCY OXYGEN VALVE OPEN
HOW EMERGENCY VALVE FEEDS PURE OXYGEN TO MASK HOSE
ROUSE

CONSTANT TESTING SAFEGUARDS FLYERS

4 ONLY NITROGEN BUBBLES REACH TOP OF TUBE TO BE MEASURED AS AN INDEX OF AIR LEAKAGE
¾" OIL SEAL
2 MEASURED SAMPLE OF GASES BEING REMOVED FROM MASK WITH HYPODERMIC SYRINGE
SPRING CLIPS
BUBBLES RISING
1 SUBJECT HAS BREATHED PURE OXYGEN FOR 5 MINUTES
3 SAMPLE IS INJECTED INTO RUBBER TUBE OF SCHOLANDER APPARATUS

Mask-testing apparatus at left is filled with pyrogallic acid (which absorbs oxygen) and potassium hydroxide (which absorbs carbon dioxide and water vapor). Another safety device is the oxygen flow indicator, above, which shows if system is working

The mask of the new equipment also differs substantially from the type formerly used. The oxygen-air mixture flows directly into the mask through a flexible hose which divides into two lines as it enters the mask, each entry being opposite a nostril. Just below the tiny microphone, at mouth level, is the exit valve. When the flyer exhales, the foul air passes through this valve. The pressure of the oxygen-air mixture in the inlet system prevents the foul air from running down the inlet pipe and contaminating the supply. When the man inhales, the outlet valve—using a soft rubber washer—flaps shut and prevents an inflow of outside air. No low-oxygen-content outside air can enter.

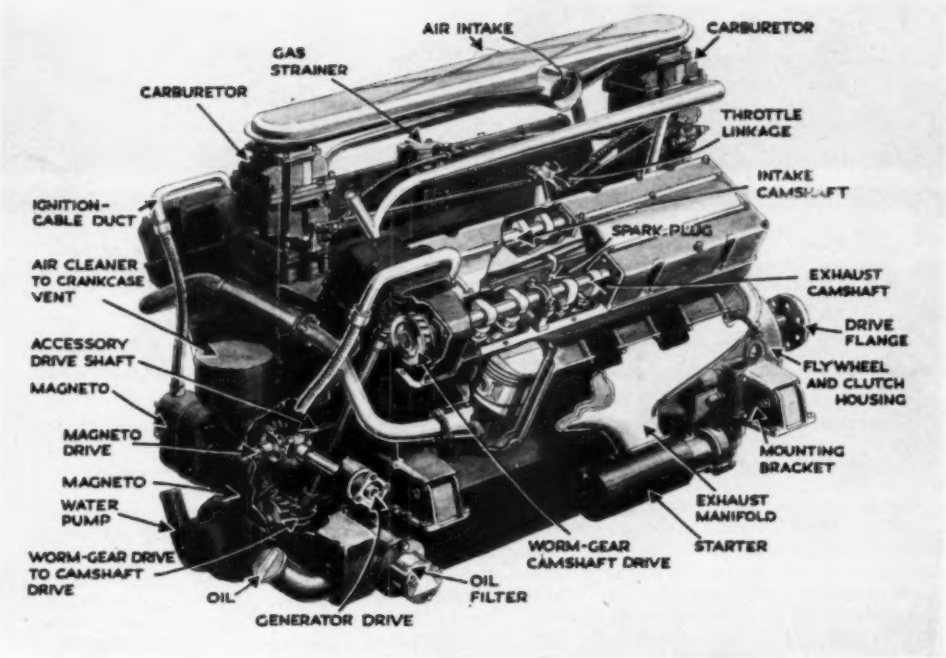
The outlet valve feeds into a duct which carries exhaust air down to the chin and neck. This prevents fogging of goggles.

The new system is equipped with a number of safety and convenience devices. A bouncing-ball flow indicator, set at the side of the pilot's cockpit, tells whether the entire system is in correct operation. This gadget is so arranged that a little ball, within a glass pipe, bounces every time the user of the mask breathes. If the ball should fail to bounce, he would know that he is not getting the proper flow of air-oxygen mixture and would open the emergency valve. When pressure in the oxygen system as a whole drops below 50 pounds—that is, when only one seventh of the total supply remains—a lamp lights up near the bouncing ball. This tells the flyers that they'd better get the plane down below 10,000 feet pretty soon, before they run out of oxygen. Sometimes a blinker device, like a winking human eye, is used instead of the bouncing ball, to show whether the regulator is in perfect operation.

On large planes—bombers and transports—each flyer has his own regulator and mask, plugging it into his station on the trunk-line oxygen-distribution system. Often, however, especially in battle the flyers have to walk around from one spot to another. For this purpose, each station has a small portable oxygen cylinder known as a "walk-around bottle." The flyer can plug this onto his mask hose when he wants to roam, replugging into the central system when he returns to his station. The bottle, when not in use, is recharged by means of a hose at the flyer's station.

Each crew member also has a small bail-out cylinder charged with oxygen under very high pressure. He wears this in a pocket in a trouser leg. If forced to parachute, he takes off his mask, puts the pipe-stem bit of the bail-out hose into his mouth, turns the valve, and jumps. He will have enough oxygen for his trip to earth.

Oxygen to supply the demand system is stored in light but very strong cylinders clamped to structural members of the plane. These are connected to a manifold or linkage of small-diameter pipes, so that all the cylinders deliver their oxygen at equal pressure to the trunk-line pipe, which passes through the fuselage and reaches each crew station. Every cylinder has its own check valve, so that if an enemy bullet punctures it the oxygen cannot blow back through the damaged cylinder and be lost. Cylinders are recharged as necessary from portable high-pressure cylinders carried on a truck, through a filler valve extending outside the fuselage.

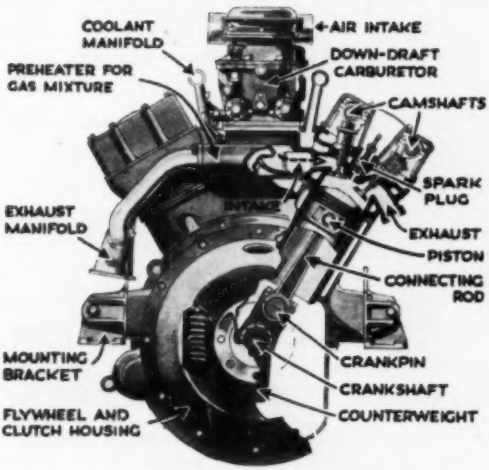


Our Medium Tanks Get a New Engine with Lots of Zip

OFF Ford assembly lines has come a tank engine that our fighting men hail as an Axis beater. It has what it takes to triumph in armored warfare—speed, dependability, and "zip." What's more, its compact construction makes it simple to service, and mass production is possible with a minimum change of available machinery. It powers our medium tanks and tank destroyers.

Ford and Army Ordnance engineers developed this engine. Its basic specifications were taken from a 12-cylinder aircraft engine of proved merit. The engineers cut it to eight cylinders, added clutch and flywheel, and altered the fuel, ignition and lubrication systems. The result is a liquid-cooled V-type engine weighing approximately 1,500 pounds and developing 500 horsepower at 2,000 revolutions a minute.

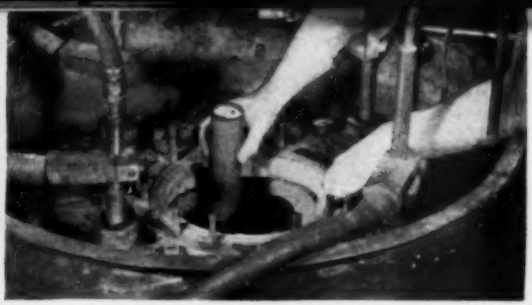
Some of its innovations: Crankshaft and flywheel are cast instead of forged; push rods are of one piece of copper-silicon steel; central power drive unit operates camshafts, water pump, oil pump, magneto, fan, and generator, simplifying service; centrifugally cast cylinder liners assure greater strength and longer wear.



End view of new tank engine with cut-away of cylinder assembly. General view at top shows other details, including the accessory drive that simplifies servicing

1

Natural Brazilian rock crystals, which are almost pure silica, are the raw material for transparent fused quartz that has found wide use in industry



2

Crushed into fine pieces, the crystals are packed into a crucible, put in an electric furnace, and heated to the fusing point of 3,200 degrees F.

FUSED QUARTZ REPLACES STEEL AND GLASS

Photographs Courtesy General Electric Company

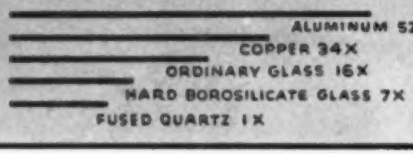
PRECISION gauges of fused quartz, used to test parts for airplane engines, now release tons of the finest tool steel for other war needs. This new application stems from one of the many remarkable properties that General Electric research workers have found in melted and solidified rock crystal.

Because fused quartz reacts almost negligibly to changes in temperature, it proves ideal for standards of length and of angles. Its high melting point, exceeding that of glass by some 1,200 degrees F., especially suits it for use in high-temperature vacuum tubes for lighting airfields. Probably the flattest things in the world are 10-inch disks of the material, ground for optical purposes by the National Bureau of Standards. Their surfaces, $1\frac{1}{2}$ inches apart, vary less than 4/10,000,000 of an inch from perfect planes.

While healthful ultraviolet rays of sunlight cannot pass through glass, fused quartz transmits them freely. Some day the material may be made cheaply enough for windowpanes. Already, germ-killing rays of ultraviolet light are being emitted by sterilizing lamps employing fused-quartz tubes, and the infrared rays called radiant heat are as easily transmitted.

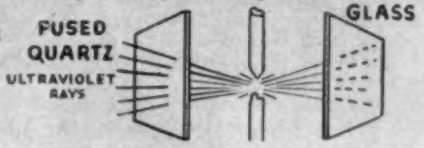
EXPANSION

Its low coefficient makes fused quartz ideal for fine gauges and optical lenses and flats



LIGHT TRANSMISSION

Ultraviolet rays of the sun or a lamp pass through fused quartz, but glass halts them

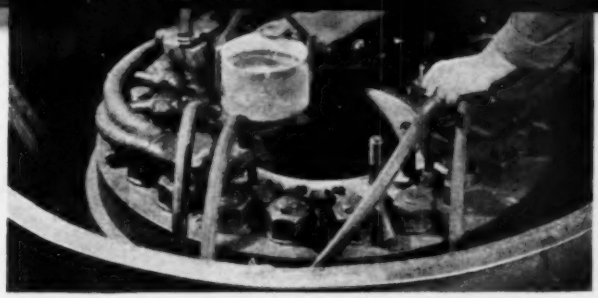


10

One end stuck into a furnace, a fused-quartz rod "pipes" sufficient heat to light a cigarette, yet its sides remain cool enough to be held by hand

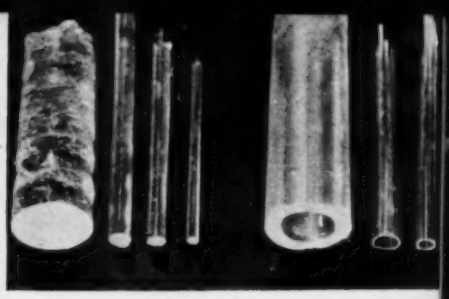
9

Laboratory ware of clear and translucent fused quartz has a high melting point, low coefficient of expansion, and very great resistance to acids



3

After it has cooled off, the ingot into which the mass of crushed quartz crystals has been fused is lifted out of the furnace for further processing



4

Rods are made from solid ingots, and tubes are worked from hollow ones. Both forms of ingots and fused-quartz rods and tubes are shown above

IN NEW USES

Drafts or spattering of molten metal from the arc lamps in motion-picture projectors sometimes crack their glass condensing lenses. Quartz lenses now eliminate the trouble. Resistance of fused quartz to chemical corrosion adapts it especially to laboratory flasks, beakers, and test tubes.

Though fused quartz has been familiar to scientists for more than a century, until recently it has been used mostly in the laboratory. Natural quartz crystals are melted in an electric furnace to make the transparent material, and a selected grade of pure sand is used for a less expensive translucent or opaque variety.

HEAT RESISTANCE

Fused quartz is often used continuously at 1,800 degrees F. and intermittently at 2,300

5

These fused-quartz blanks, 12 inches in diameter, will be made into 10-inch optical flats varying less than 4/10,000,000 inch from a true plane

6

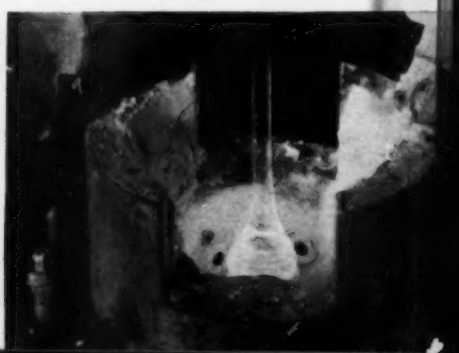
When a hollow fused-quartz ingot is worked into a tube, it is first placed in a furnace where it is again heated—this time to make it pliable

8

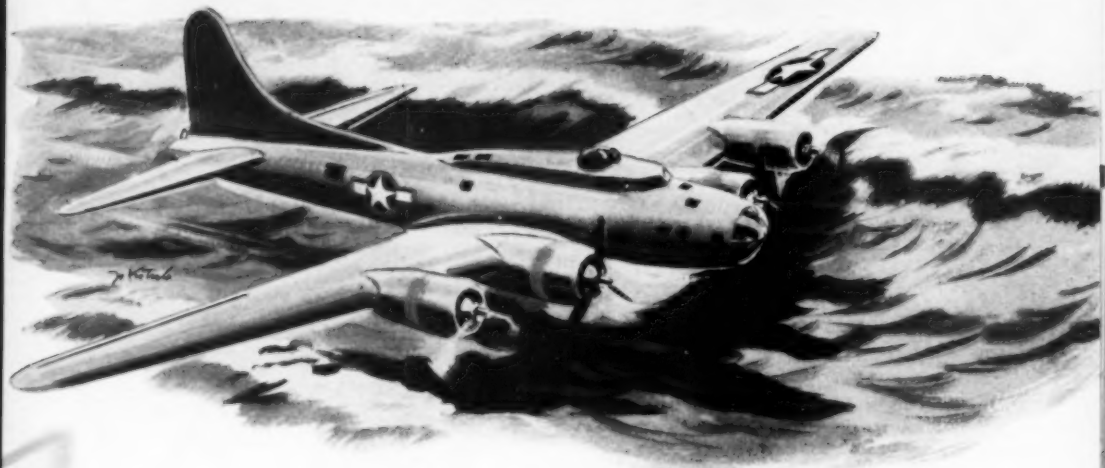
Because of a high resistance to thermal shock and freedom from distortion caused by heat of friction, fused quartz is ground and lapped faster than glass

7

Then, while part of the ingot remains in the furnace, it is drawn into a long tube of the diameter required. The solid ingots are worked into rods in the same way



How to Ditch a Fortress



What happens to the crew of one of Uncle Sam's big land bombers when it is forced down on the sea? It may be only a matter of seconds before the plane sinks, but every man knows his job and does it.

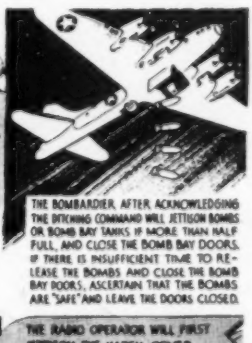
WHEN the order, "Prepare to ditch," comes over the interphone system of one of our big bombers, 30 seconds may mean the difference between life and death for the crew. For that warning, sounded by the pilot, is notice that the big land plane is being forced down on the sea, and 30 seconds afloat without seaplane landing gear may be all that can be expected even under the most favorable conditions.

So well trained are our bomber crews, though, that these emergency landings on

Recommended
DITCHING
PROCEDURE
AS COMPLETE EVACUATION OF THE AIRPLANE SHOULD NOT TAKE OVER 30 SECONDS, PRE-FLIGHT PRACTICE DRILLS SHOULD BE PARTICIPATED IN BY ALL CREWS WHO ARE TO MAKE A FLIGHT OVER WATER OR WHOSE OPERATIONS ARE GENERALLY OVER WATER.

A COMPLETE AND CAREFUL INSPECTION OF EMERGENCY EQUIPMENT SHOULD BE MADE BEFORE EACH LONG OVERWATER FLIGHT. CHECK LIFE RAFTS, EMERGENCY KIT BAGS (PROVISIONS) AND EMERGENCY RADIO EQUIPMENT. THE KIT BAGS AND RADIO ARE STORED AFT OF THE RADIO COMPARTMENT.
FOR LIFE RAFTS: FIRST DISCONNECT CO_2 CABLES FROM LATCH HERE
THEN PULL THE BLUE LIFE RAFT HANDLES IN THE RADIO COMPARTMENT

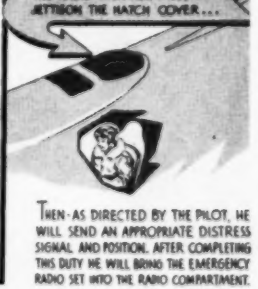
BOMBARDIER DITCHING
TOP GUNNER DITCHING
NAVIGATOR DITCHING
EACH CREW MEMBER WILL ACKNOWLEDGE THE DITCHING COMMAND OVER THE INTERPHONE.


THE BOMBARDIER, AFTER ACKNOWLEDGING THE DITCHING COMMAND WILL JETTISON BOMBS OR BOMB BAY TANKS IF MORE THAN HALF FULL, AND CLOSE THE BOMB BAY DOORS. IF THERE IS INSUFFICIENT TIME TO RELEASE THE BOMBS AND CLOSE THE BOMB BAY DOORS, ASCERTAIN THAT THE BOMBS ARE "SAFE" AND LEAVE THE DOORS CLOSED.

WHEN IT BECOMES EVIDENT THAT THE AIRPLANE IS TO BE FORCED DOWN AT SEA DUE TO LACK OF FUEL OR THAT AN ALTITUDE OF AT LEAST 1000 FEET CANNOT BE MAINTAINED —

PREPARE TO DITCH!
— THE PILOT GIVES THE "DITCHING" COMMAND OVER THE INTERPHONE.
Warning! THIS COMMAND MUST, IF POSSIBLE, BE GIVEN BEFORE THE FUEL SUPPLY IS LESS THAN REQUIRED FOR 15 MINUTES OF FLIGHT. THE CHANCES FOR A SUCCESSFUL DITCHING ARE MUCH GREATER IF POWER IS USED.

THE NAVIGATOR WILL DETERMINE THE POSITION AND INFORM BOTH PILOT AND RADIO OPERATOR.
HE WILL TAKE WITH HIM NECESSARY INSTRUMENTS TO MAKE SIMPLE COMPUTATION WHILE ON LIFE RAFTS.


THE RADIO OPERATOR WILL FIRST JETTISON THE HATCH COVER...
THEN — AS DIRECTED BY THE PILOT, HE WILL SEND AN APPROPRIATE DISTRESS SIGNAL AND POSITION. AFTER COMPLETING THIS DUTY HE WILL BRING THE EMERGENCY RADIO SET INTO THE RADIO COMPARTMENT.

THE SIDE GUNNERS WILL JETTISON THE SIDE GUNS AS THEY MAKE VERY DANGEROUS BATTERING RAMS. IF THERE ARE NO SIDE GUNNERS, THIS DUTY SHOULD BE GIVEN TO OTHER CREW MEMBERS BEFORE FLIGHT
A CREW MEMBER, APPOINTED BEFORE FLIGHT WILL TAKE THE EMERGENCY KIT BAGS TO THE RADIO COMPARTMENT
THE EMERGENCY RADIO IS STORED HERE
TAIL GUNNER SHOULD CLOSE THIS DOOR BEHIND HIM
HATCH SHOULD BE JETTISONED
THESE DOORS ARE LEFT SNAPPED OPEN
AFTER COMPLETING HIS INDIVIDUAL DUTIES EACH MEMBER GOES TO THE RADIO COMPARTMENT WHICH IS THE CRASH STATION FOR ALL BUT THE PILOT AND CO-PILOT.
BOTH PILOT AND CO-PILOT WILL STRAP THEMSELVES IN THEIR SEATS
THE PILOT WILL DIRECT THE CO-PILOT TO CUT THE TWO INBOARD ENGINES (IF THE TWO OUTBOARD ENGINES ARE FUNCTIONING SATISFACTORILY) AND TO FEATHER THEIR PROPELLERS
IF THE SIDE WINDOWS ARE TO BE USED AS EXITS, SLIDE WINDOWS OPEN THEN CLOSE, INSURING FREEDOM OF OPERATION. LEAVE THEM CLOSED DURING DITCHING. CAUTION: PLACE AXE HANDY IN EVENT OF JAMMING!
BE SURE ALL EMERGENCY EQUIPMENT IS IN THE COMPARTMENT. THROW OVERBOARD ANY EQUIPMENT THAT MIGHT COME LOOSE.
RADIO OPERATOR'S SIDE
REMOVE CUSHIONS FROM SEATS FOR HEAD PROTECTION & TAKE CRASH POSITIONS. DO NOT TAKE A POSITION IN CENTER OF COMPARTMENT AS BALL TURRET UPPER STRUCTURE MAKES THIS UNSAFE. BRACE HEAD AGAINST SOLID STRUCTURE IF POSSIBLE. DO NOT LEAVE THESE POSITIONS UNTIL PLANE HAS COME TO REST AS THERE WILL LIKELY BE MORE THAN ONE SHOCK.

water have lost much of their hazard, at least insofar as it relates to loss of life or injury in the actual landing. Each man knows his station, and he goes to it, ready to act instantly with the final impact of the plane on the water. Each has his specific duty to perform, and he does it without hesitation and without delay so that he and his mates will be assured of at least a fair chance of survival in their life rafts. In addition, each man also knows duties of the others in the crew so that no hitch will occur should any be too seriously injured to carry out his part.

Specific instructions, known officially as the "ditching procedure," have been prepared by the Boeing Aircraft Company and the Army Air Forces. The steps apply particularly to Boeing's big Flying Fortresses, but in general they are also followed for a water landing made by any other multimotored land plane. Illustrations and instructions from the "ditching procedure" are given on this and the preceding page.

THE PILOT SHOULD ATTEMPT TO SET THE AIRPLANE DOWN IN A TROUGH (THIS IS USUALLY CROSSWIND). THE TWO OUTBOARD ENGINES ARE USED FOR CONTROL AND TO FLATTEN THE APPROACH. THE LANDING GEAR SHOULD BE UP, THE FLAPS LOWERED MEDIUM, AND THE IGNITION SWITCHES CUT A FOOT OR SO ABOVE THE WATER.
DO NOT STALL IN!
IF TAIL IS DOWN FUSELAGE IS LIKELY TO BREAK HERE
WATER SHOULD BE TOUCHED AT ABOUT 90 MPH. COME IN AS LEVEL AS POSSIBLE. ALL MEMBERS SHOULD HAVE LIFE VESTS ON, PARACHUTES REMOVED AND SHOULD HAVE ON ALL EXTRA CLOTHING TO BE WORN ON RAFTS. IN NIGHT DITCHING TURN OFF ALL BRIGHT INTERNAL LIGHTS AND USE ONLY THE AMBER LAMPS.
PILOT AND CO-PILOT WILL EXIT THROUGH THEIR SIDE WINDOWS OR THROUGH THE RADIO COMPARTMENT HATCH (DECIDE WHICH BEFORE FLIGHT)
➡ CAUTION: NO CREW MEMBER SHOULD INFLATE HIS LIFE VEST UNTIL HE HAS EMERGED FROM THE AIRPLANE.
DO NOT JUMP ON AN INVERTED RAFT AS THIS WILL EXPEL AIR TRAPPED UNDER IT AND RIGHTING BECOMES MORE DIFFICULT
IF THE LIFE RAFT IS INFLATED UPSIDE DOWN ONE MAN SHOULD JUMP IN THE WATER AND RIGHT IT. IF THERE ARE HANDLING PATCHES ON BOTTOM OF RAFT, GRASP THEM WITH BOTH HANDS AND WITH KNEES ON BUOYANCY CHAMBER LEAN BACK AND PREPARE TO BE SUBMERGED FOR A MOMENT. EVEN THE LARGEST RAFT WILL TURN OVER.
LIFE RAFT HANDLES
AS SOON AS THE AIRPLANE HAS COME TO REST THE PREDESIGNATED MEMBER WILL PULL THE LIFE RAFT HANDLES.
FIRST MAN OUT ASSIGNED TO BRING RAFTS UNDER CONTROL
ONE MAN ASSISTS OTHERS OUT-CHECKS TO SEE ALL EMERGENCY EQUIPMENT TAKEN
DURING PRE-FLIGHT DRILL MEN SHOULD BE ASSIGNED TO EVACUATION DUTIES. EACH MAN SHOULD BE FAMILIAR WITH THESE SO THAT IN CASE OF ACCIDENT ALTERNATE MEN CAN CARRY ON. EACH MAN SHOULD KNOW HIS ORDER.
THE RAFTS SHOULD BE FASTENED TOGETHER SO THEY WILL NOT DRIFT APART
ONCE ABOARD THE RAFTS A CHECK SHOULD BE MADE TO LOCATE LEAKS. REPAIR. THEM WITH THE KIT PROVIDED IN THE RAFT KEEP AWAY FROM THE AIRPLANE IF IT FLOATS BUT STAY IN THE VICINITY IF POSSIBLE. DO NOT REMOVE WET CLOTHING DO NOT TALK MORE THAN NECESSARY, IT DRIES THE MOUTH. DO NOT MOVE MORE THAN NECESSARY IT TAKES ENERGY
A SIGNAL KIT CONTAINING A PISTOL AND FLARES IS IN A WATERPROOF SEALED POCKET OF THE LIFE RAFT IT MAY BE ADVISABLE TO LEAVE THE KIT SEALED IN THE POCKET UNTIL A SHIP OR PLANE IS SIGHTED SO AS TO HAVE DRY SIGNAL EQUIPMENT

1 This huge floor at the Army Air Forces School of Applied Tactics, Orlando, Fla., is a map of the China coast. To train officers in air defense, electric "jeeps" (left) roll over it representing bombers

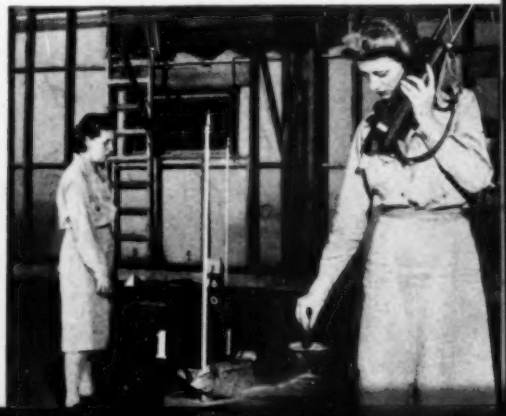
Electric "Jeeps" Aid Air-Defense Training

2 Wac "spotters" stationed in balcony posts on the four walls take sights on an invader and report its course, speed, height, and other data

3 At the main filter board, duplicating equipment of a defense center, this information is used to determine the objective and arrival time of attackers

4 From the plotting table, orders are flashed to "interceptor bases" on the big map floor, giving courses on which enemy can be headed off

5 Getting orders on a walkie-talkie, a Wac sets the controls of her interceptor "jeep." It should meet the "bomber" before the latter hits its target



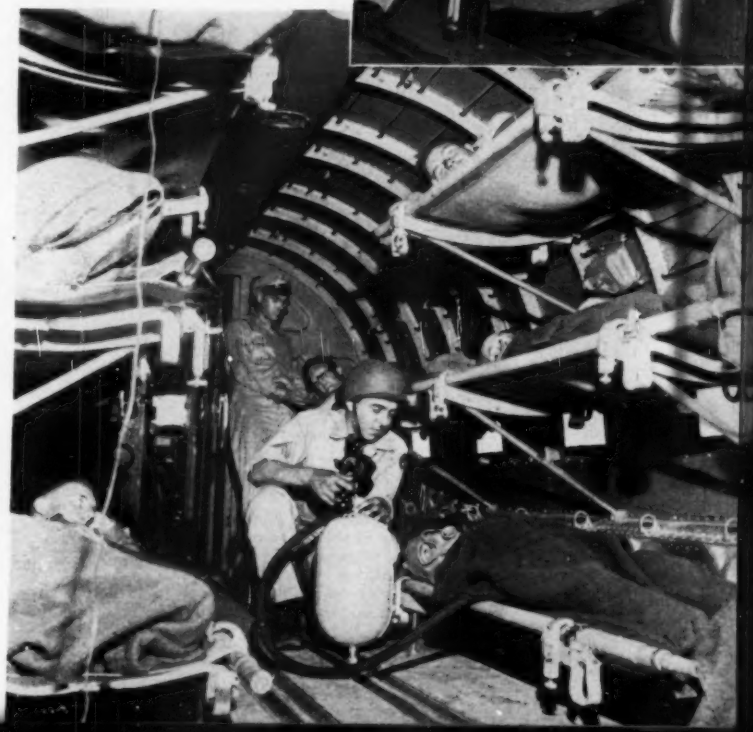
CARGO PLANES DOUBLE AS AIR AMBULANCES

FLYING AMBULANCES, converted from giant transports that carry men and matériel into battle, are being used to speed the wounded to base hospitals. Cargo planes going up to the front, they are hospital ships coming back. Many are big C-47's like that shown above at a demonstration at the School of Applied Tactics in Florida

STRETCHER SUPPORTS that can be stored under the floor boards when not in use are easily attached to the bulkheads of the fuselage, as in the photo at right. Stretchers are held on with clamps so they will not be thrown off if the plane goes into a sharp maneuver. Medical equipment, under the control of a flight surgeon, is complete, including oxygen tanks, as shown below, and all other necessities for sustaining life on the flight to the base hospital. Soldiers' gas masks, with filter removed, are used for oxygen masks

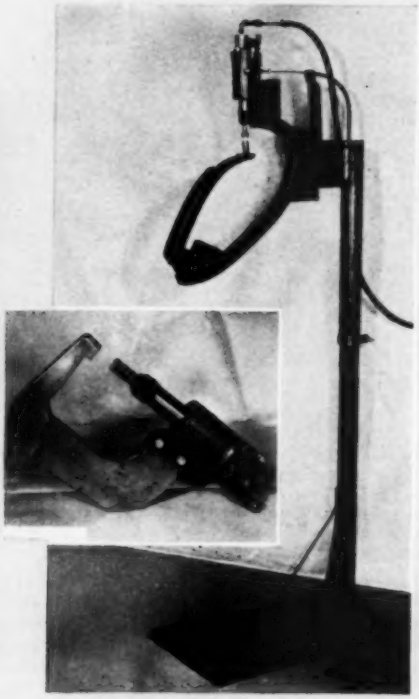
AIR evacuation of sick and wounded soldiers is being hailed as a great saver of lives in this war. Big cargo planes, flying matériel into battle zones, are converted into swift aerial ambulances for the trip back.

In New Guinea, where transfer over mountains would take three weeks, planes cut the time to less than one hour. A critically injured soldier was brought from Indo-China to the United States in eight days, Brig. Gen. David N. W. Grant, Air Surgeon, reported recently. By land and sea, the trip might have taken three months.



NEW Tools

ALL-PLASTIC GOGGLES, set with shatterproof Plexiglas lenses that insure clear and undistorted vision, are now manufactured for war workers by the Watchemoket Optical Co., of Providence, R. I. Weighing less than two ounces, the full-framed goggles fit right over prescription glasses. Perforations in the frame prevent fogging, and special filters can be snapped on the lenses for glare protection



ONE-MAN RIVETING with a vibrator that is controlled by the "travel" of the driving set has just been perfected by the Buffalo Airplane Division of Curtiss-Wright. This "jam riveting" can be done with either a hand or standing vibrator, and is especially valuable on tricky jobs like cowling manufacture. Since the gun is internally controlled, the work is unusually accurate

A CLEANING CAGE that makes short work of small parts like gauges and bearings has been designed by the L. & R. Mfg. Co., Newark, N. J. Run by electricity, the unit is as simple to use as a washing machine and is easily operated by a woman. The speed of the whirling cage, which holds the dirty parts, can be adjusted for varying needs. Entire portable unit weighs less than 50 pounds

ELECTRODE HOLDERS slim enough to work in tight places and weighing only 12 ounces are offered by Jackson Products, of Detroit. Insulated, the holder guards welders' eyes from flash and cuts out waste due to touching work with bare holders. It holds rods up to 3/16 inch

Brain-Teasers in Uniform

SEVEN PROBLEMS WITH A WARTIME SLANT

1. His Dollars Make Sense

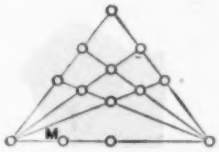
A MAN puts half his week's pay into war bonds and stamps. After buying them, he has left just as many cents as he had dollars, and half as many dollars as there were cents in the envelope when he received it. What is his weekly pay?

2. Bombing by Halves

A BOMBARDIER is told to set fire to four enemy towns. Over the first one he drops half his bombs and half a bomb. Over the second he drops half the bombs he has left plus half a bomb. Over the third town he drops half the remaining bombs and half a bomb. Then, taking count, he finds that he has 36 bombs left for the fourth town. What was his original load?

3. Defense Without Design

A FIELD of pillboxes is laid out as illustrated here. Corporal Fussbudget, gunner, whose secret passion is design, is considerably upset by the fact that his pillbox, M, plays no essential part in the design created by the other boxes. How might the Army engineers have laid out the field to put all 13 into a similar pattern, and so satisfy the corporal's aesthetic sense?

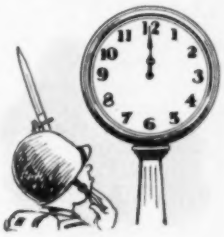


4. Ships That Pass in the Jungle

BOATS A, B, and C, carrying men up a narrow jungle river, meet boats D, E, and F, bringing down wounded. There is no room to pass, but there is a small basin at P which will admit any one of the boats singly. How can the boats pass?

5. It's Later Than They Think

A CERTAIN street corner in an occupied coastal city is guarded day and night by German sentries. The watch is changed every time the two hands of the clock coincide. At what times, within 24 hours, will the guard be changed? If no guard is on duty there more than once each week, how many will serve on that corner from a minute before Monday noon to a minute after Sunday noon?



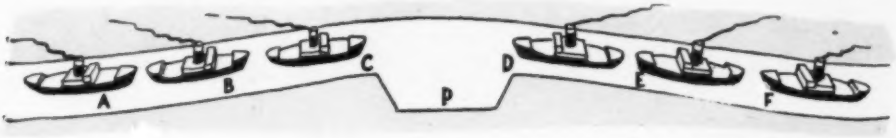
6. Japs with a Price on Their Heads

SUPPOSE Army Intelligence offers a bounty on Jap prisoners brought in for questioning. Outfit A brings in half a dozen dozen Japs and is paid a dozen dollars the half dozen. Outfit B brings in a dozen dozen Japs and receives half a dozen dollars the dozen. Which outfit receives more money?

7. Getting in Under the Wire

IMAGINE, if you can, a row of telephone poles set up to girdle the earth at the equator. Suppose also the earth is a perfect and even-surfaced sphere of exactly 25,000 miles circumference. Now string on the poles a high-voltage wire 100 feet longer than the circumference of the earth, so that when the current is thrown on there is a charged circle around the earth concentric with the equator. Could a man pass under this wire at the equator without touching it? Could a ship pass under it?—E. J. DINTRUFF.

See page 220 for answers.



How You Can See the Weather

Great currents in the atmosphere produce the changes that make us call it a "nice day"—or swear!

By DON ROMERO

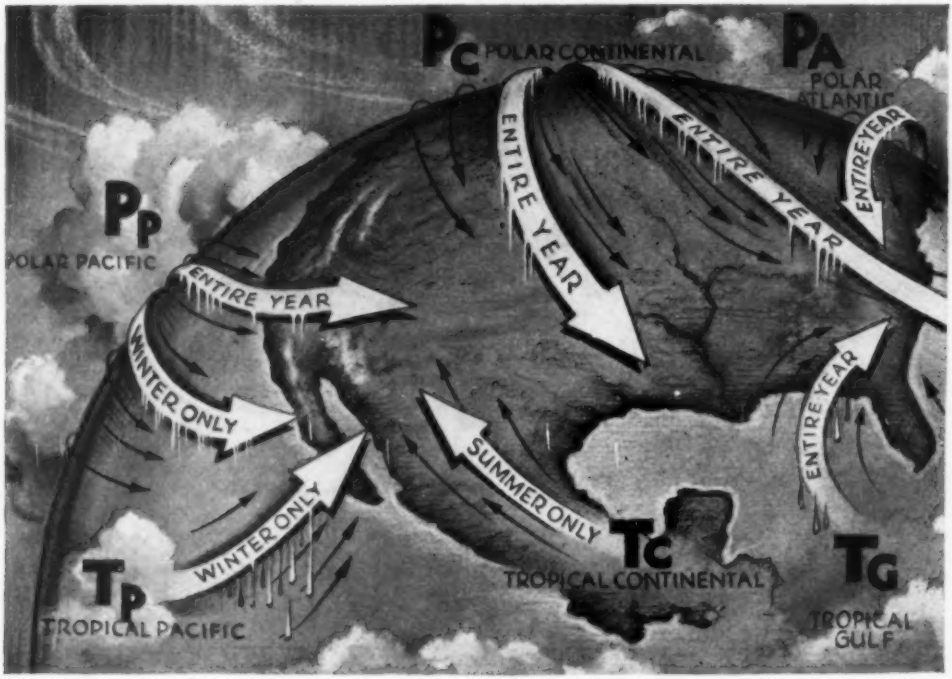
Drawings by ERIC SLOANE

WHEN Mark Twain said that everybody talks about the weather but nobody does anything about it, he did not envision the spectacular advances that lay ahead in meteorology. Nor did he foresee the day when the airplane would be as common as the horse and buggy; and when, to every pilot who took his plane into the air, the weather, instead of being a subject of casual conversation, would be a matter of life and death.

Up to now, most of us have looked upon weather forecasting as pretty much a hit-and-miss affair. Meteorologists talked solemnly of rising pressures and departing storm centers, but few of us had faith in the prediction that tomorrow would be "fair and warmer." Often we were just as ready to listen to some old-timer who, with an eye for the weather, would cast a knowing glance at the sky and then recite some ancient jingle such as "Mackerel sky, not three days dry."

Today, however, meteorology—largely through the medium of aviation—is bringing home to many of us a new and entirely

WHERE AMERICA GETS ITS WEATHER Governing the weather of the United States are a number of huge bodies of air, each of which takes its name from the region from which it comes and where it has matured. Sweeping across the country in the directions indicated on the drawing below, these major air masses determine almost entirely the weather of the areas over which they pass. In turn, however, they are often affected

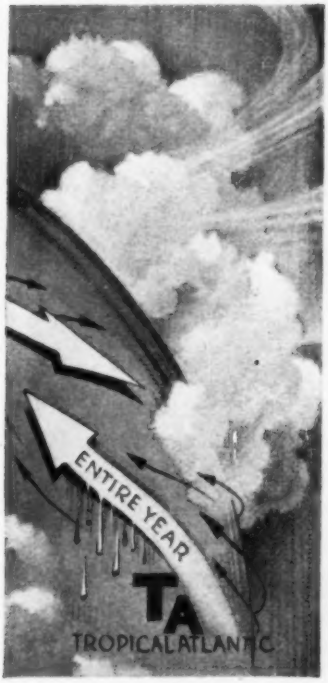


understandable concept of the enormous mass of air that floats over our heads. It is taking that gigantic ocean and showing us not only how to "see" it, but also how to feel it and smell it!

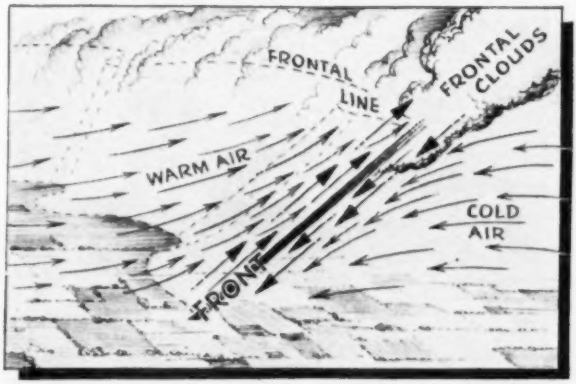
Known as Air Mass Analysis, this new concept is based on the studies and experiment of Vilhelm Bjerknes, who, with other Norwegian meteorologists, was one of the pioneers in the science of "long-distance" weather forecasting. Instead of visualizing the atmosphere as one vast sea whose vagaries accounted for weather that could be predicted with certainty only a few hours in advance, Bjerknes discovered that the atmosphere actually is composed of several giant individual bodies of air, each of which is distinguished by its own heat, humidity, and clarity. Bjerknes also discovered that, at definite times of the year, these bodies of air moved in well-defined paths across the earth's surface. He also found that the weather that prevailed in a given area was governed almost entirely by the type of air that was occupying that area at that time.

Known by the outlying regions from which they come and where they have been conditioned, several of these huge air masses dominate the weather of the United States. The Tropical Atlantic and Gulf airs are warm, humid currents that have been cooked up by the intense sun and warm sea water of the Caribbean region. The Polar Atlantic is a cold, low-clouded, drizzling current that sweeps down from the Grand Banks off Newfoundland. The Polar Continental is a cold and lively current of air. From the deserts of Mexico and Arizona comes the Tropical Continental—a burning, arid body of air that fortunately gets only as far as Oklahoma, Colorado, and Kansas. Up through Southern California comes the Tropical

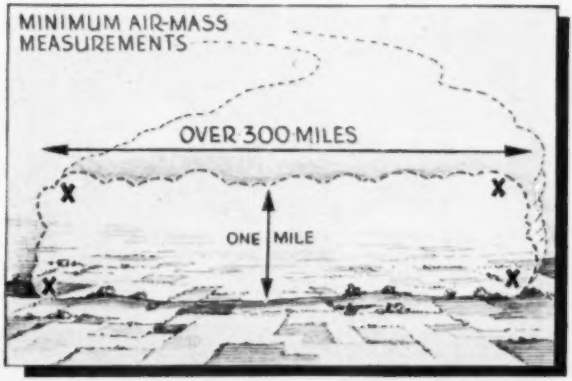
by the temperature, humidity, and topography of the ground. Changes in the weather come as a result of one air mass invading an area occupied by another



AIR MASSES AND THEIR "FRONTS"



"Fronts" are set up when two air masses of different types come in contact with each other. It is here greatest turbulence occurs



Here a mass is shown moving over a ground area. As long as it remains unaffected by the contact, the mass will have the same specific humidity and potential temperature at all "X" points

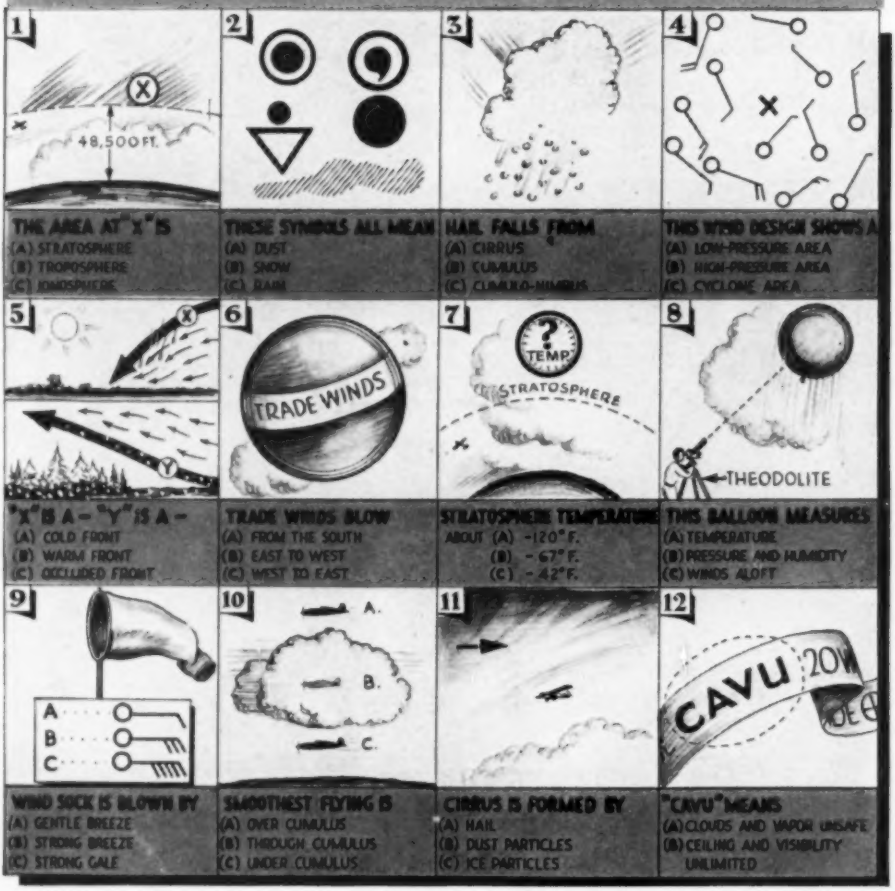
Pacific, a soft, lazy kind of air that is believed to originate in the South Seas. The cool, moist Polar Pacific that chills Seattle comes all the way from Siberia. The eighth body of air—Sec Superieur—is believed to originate in the stratosphere over the Galapagos Islands.

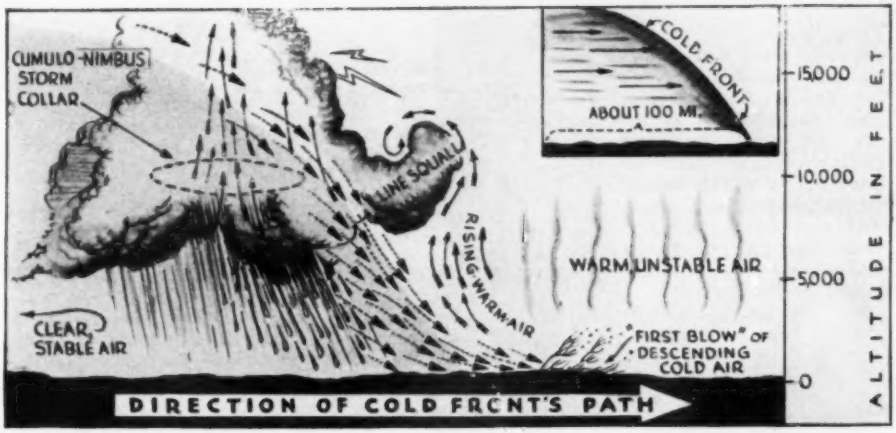
One thing that must be kept in mind is that while these bodies of air largely determine the weather, they, in turn, are often affected by the areas over which they pass. An air sweeping down over a lake region is very likely to bring weather that is raw as well as cold. A warm, moist body of air moving over cold ground will be responsible for cloudy weather—caused by the air's lower layer being chilled and thus having some of its moisture condensed into visible form. A clear, cold body of air passing over a hot area will pick up little heat from the sun, but will allow its rays to continue to heat the earth's surface, and then absorb heat from that.

Even the topography of the ground can, for a time, change the character of an air mass. Coming in at a low level, a warm current can be carried up the side of a high mountain range and be tossed high into the air—with a resulting condensation of its moisture that may keep the mountain range

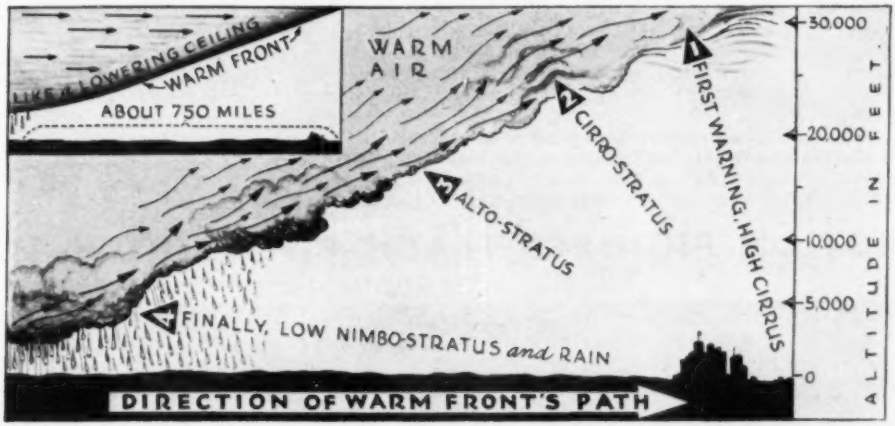
What Do You Know About Weather?

This not-too-difficult quiz will help you to test your knowledge of meteorology. Under each question are some possible answers, only one of which is correct. Check your answers with those on page 94





Being heavy, the invading cold air will tend to come in low, lifting the warm air as it pushes it back. In the northwest will appear a solid cloud bank—the actual "front"—which will build up as it advances



Invading warm air, being light, will come in "over the top." First warning will be "mares' tails," followed by progressively lower clouds, and rain. An invading cold air will then start the cycle all over again

snow-capped through an entire hot summer. Crossing the mountain peaks and rolling down the other side, this same air mass will be heated up again by the increased atmospheric pressure, and in its now drier state will be so thirsty for moisture that it will suck the surrounding sky dry of every cloud.

Picking up heat from its contact with a warm area, the lower layer of a cool air mass will become light and will start to rush upward in the form of giant air bubbles, some of them hundreds of feet in diameter. A plane, flying along in cool, stable air, will get a sudden jolt as it is caught up in one of these swiftly rising currents, and then will be dropped with equal suddenness as it escapes from the bubble area. Although pilots of passenger planes naturally strive to avoid such turbulent spots, they can be of help to a pilot who has to gain altitude quickly. All he needs to do is to keep circling in one of these bubble areas and let it shoot him skyward at a much faster rate than he could climb. The same is true—and of greater importance—to the glider pilot, who must rely solely on upward currents of air to stay aloft.

As important as the discovery of the air masses themselves is the locating of their "fronts"—the border lines that separate one mass from another. Modern meteorology is teaching us to "see" these invisible masses by observing the action that results when one mass drives out another, for it is at

these fronts that "cloud" banners most clearly define the otherwise invisible air currents. The greatest local disturbances are associated with these fronts.

One of the ingenious methods by which schools of meteorology are teaching students to "see" individual air masses involves the use of warm water that has been colored red, and cold water that has been colored blue. When poured into a glass and viewed from the side, these two types of water can be seen to set up the same kind of "fronts" that occur in the atmosphere; the cold, heavy water tending to push downward; the warm, light water surging upward.

"Feeling" and "smelling" the weather, long considered whimsical notions of forecasting, have also been reinterpreted for us in a practical and understandable way. "Smelling rain in the air," for instance, means that we are in a low-pressure, or storm, area; odors from swamps or other low, moist places, formerly held captive by the high pressure of good-weather air, have now been released into the atmosphere. When we say that "it feels like rain," it merely means that we are reacting to a falling pressure, which has a definite physiological effect on us, such as making us depressed or irritable. Other similar storm signals are the game leg that starts to pain, and the corn that begins to ache.

Almost simultaneously with the discovery of "long-distance" weather forecasting came the realization that here was a powerful weapon of war. Soon after the Norwegian pioneers announced their findings to the world, the Germans started an intensive study of modern meteorology. Following close on their heels came the Japs, who today have a first-rate weather bureau.

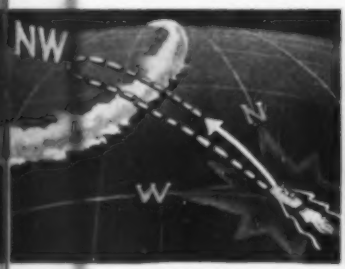
How well the Germans have learned the new science is evidenced by the spectacular escape of their battleships *Scharnhorst* and *Gneisenau* through the English Channel under the very noses of Britain's land-based bombers. At the time, it seemed as if the Germans had taken a 100-to-1 chance, and won. Actually, with characteristic Teutonic thoroughness they had timed the escape to the day—a day which their meteorologists long in advance had advised the Admiralty would bring the worst weather that the Channel had seen in years. Even if the

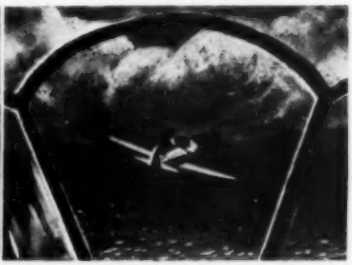
ANSWERS TO QUIZ ON PAGE 92

1—A	5—A; B	9—A
2—C	6—B	10—A
3—C	7—B	11—C
4—B	8—C	12—A

MOTION PICTURES TEACH PILOTS HOW TO

These drawings are from one of a series of aerological





1 Carrier-based planes are sent on scouting mission that will take them through cold front on both outward and return flights

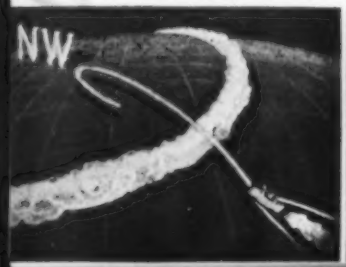
2 Cumulus clouds appear on northwest horizon, and extend far to left and right. Plane drift is northward, indicating southerly winds. Air is unstable

3 Section leader now knows that he is approaching the cold front. Low cloud bases and a dark, unbroken rain area indicate a storm

7 On return trip, flight is at a low level, for cloud bases have lifted and clear spaces are to be found in heavy rain area

8 Selecting a light area, the leader goes into the front at right angle. To avoid the storm, he flies as close to the ocean surface as safety permits

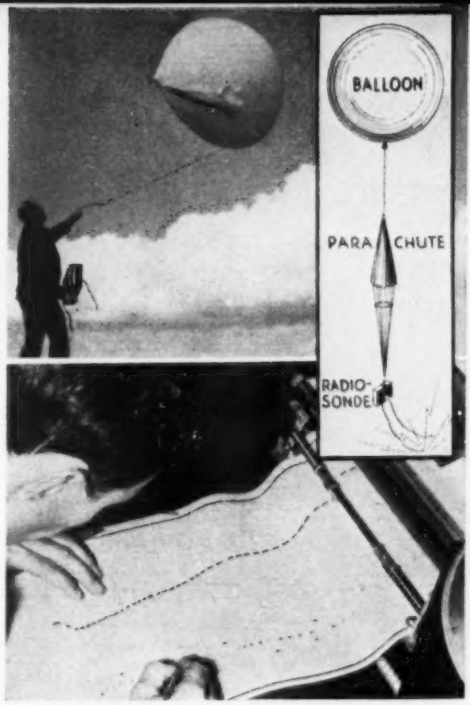
9 Close on the tail of their leader, the other planes wing their way into the "hole" he has found. The direction of the wind is now northerly



British bombers had known that the ships were in the Channel, they would have been helpless, for a "pea-soup" fog enveloped the vessels as they raced for the open sea.

When Germany launched its invasion of Poland, the Poles, fighting fiercely to resist an already overpowering foe, cursed the luck of the invaders in the excellent weather that was aiding their advance. Actually, the Germans had waited for months for the weather to become their ally, and had not dared turn a wheel before their experts had guaranteed them two absolutely dry and clear weeks in which to move their tanks and trucks.

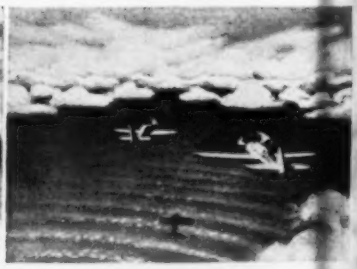
Most Americans like to believe that the Japs chose December 7 for their attack on Pearl Harbor because it was a Sunday, when normally the base would be enjoying "a day off." More likely the truth is that they carefully selected a time when it would be good sailing weather for their carriers, good flying weather for their planes, and a clear day for bombing an unsuspecting foe. In one notable instance, however, Jap meteorologists badly misread the signs. In the Bismarck Sea engagement, the Jap armada was advancing under the protective screen of a thunderhead when suddenly the clouds evaporated into a clear sky and left their battleships and transports sitting like ducks on a calm lake. *(Continued on page 220)*



RADIOSONDE An invaluable weather device, this robot broadcaster sends down to earth a steady stream of atmospheric data as it ascends at the tail of a balloon. In the stratosphere, the balloon bursts, and the radiosonde floats to earth supported by a parachute

AVOID THE DANGERS OF A "COLD FRONT"

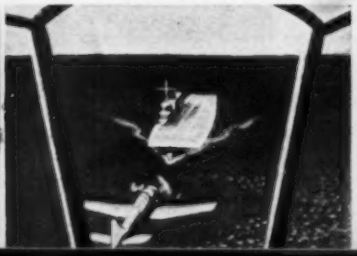
training films made by Walt Disney for the U. S. Navy



4 Leader avoids storm by climbing. When temperature of outside air drops, he makes drift correction to right to make up for change in wind

5 Once the flight section is past the storm line, the leader takes it down until the surface of the water can be seen through the clouds

6 At this point the planes descend to scouting level and proceed on their assignment of searching the designated area



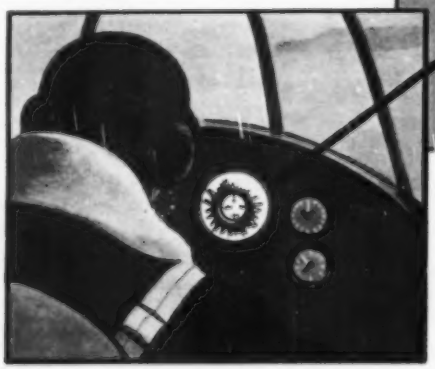
10 In a few minutes the air temperature begins to rise, indicating that the planes are through the front and in southerly winds

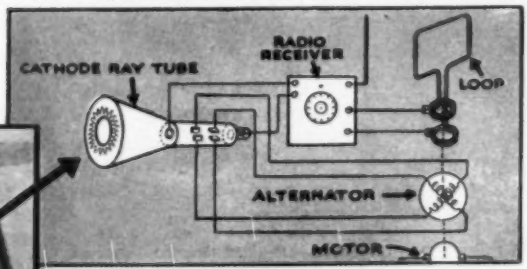
11 In another minute or two, all of the planes have popped out the other end of the "hole," and in front of them is nothing but clear sailing

12 Accomplished with apparent ease, this mission could have cost lives if leader had not shown good weather sense

INFRARED DE-ICING RADIATORS are proposed by J. D. Altemus, of Roslyn, N. Y., as a new solution to one of aviation's most insistent problems. Mounted on the nose and propeller hub, the radiators would focus their beams on the propeller blades and leading edges of the wings to keep them above icing temperature.

TRACER BULLETS that ignite fast enough for use in short-range tommy guns have been designed by Col. Sterner St. P. Meek, U.S.A. By increasing the exposed area of the igniter compound on which the propellent powder acts, and shortening the fire's path through the compound, the tracer material is made to ignite almost instantly after the discharge.

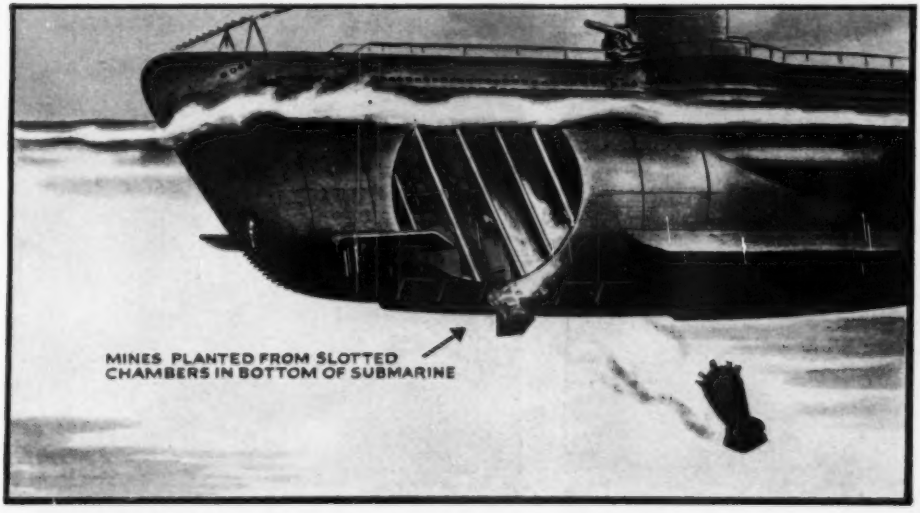




A NEW DIRECTION FINDER employing a cathode-ray oscilloscope has been developed for planes by Donald G. Little, of Baltimore. As the loop antenna revolves, a circular wave pattern appears on the oscilloscope screen, which is calibrated to 360 degrees. When radio signals begin to come in, a depression appears in the pattern to indicate the direction from which they are being sent.

FLAME-THROWING TANKS that are said to be able to spew out their jets of fire a distance of 110 yards are reported to be among Germany's new "secret weapons." The tanks are also said to be equipped with a smoke-screening device that makes it possible for them to envelop themselves in a thick artificial fog in a matter of a few seconds.

MINE-LAYING U-BOATS are now believed to be in use by the Germans in an effort to destroy the bridge of ships carrying supplies to our allies and overseas forces. In addition to torpedoes, the U-boats carry a substantial load of mines which they can plant while submerged by dropping them from slotted chambers.



Fighting on a thousand fronts is 'Ghost Light' OUR NEW WEAPON IN THE DARK

By JEAN ACKERMANN

A LEADER of a night scouting party consults his map. As he is near the enemy lines, it would be suicide to strike a match or use a flashlight. No need. Printed in luminous ink, lines of the map shine dimly but clearly in the dark.

The party moves on. Lest his men become separated from him, the leader wears a faintly glowing button on his back. Similarly, to the rear, ghostly processions of blacked-out tanks and troop-loaded trucks are advancing in follow-the-leader style, each guided by a spot of luminous paint on the one ahead.

Now the scouts have completed their mission. To mark directions for the secret troop movement, they have daubed roads and trees with splotches of ordinary-looking paint. When a soldier turns the invisible beam of a special black-light flashlamp upon one of the painted direction markers, it lights up as plainly as a traffic signal.

Through 30 centuries, from the time when ancient Egyptians used light-emitting minerals to create a mysterious glow around temple altars, the phenomenon called luminescence remained no more than a showy novelty. It turned up in the theater, where seemingly unoccupied shoes tapped brightly across an unlit stage, and where costumes and scenery gave striking luminous effects. It came down to earth, and into everyday life, in fluorescent lamps for homes, offices, factories, and outdoor displays. From this beginning, its practical uses on war and home fronts are multiplying constantly.

According to a recent order, all ships of more than 3,000 tons using New York Harbor must have doors, stairways, control valves, steam pipes, and other important points marked with luminous paint. Thus, in case a torpedo puts the regular lighting system out of commission, sailors can still make repairs or find their way to lifeboats. Direction markers pointing to air-raid shelters, and the shelters themselves, may use "firefly" illumination in total blackouts. Setting an example for motorists in air-raid

CIVILIAN USE. Street curbs, doorknobs, stairways, light switches, and other similar points can be covered with luminous paint to guide people safely through a blacked-out area

Fashion has not neglected to avail itself of the novel effects made possible by luminescence, using it on hats, dresses, capes, stockings, hairdress, and jewelry. In the theater, too, it often appears in settings and costumes

THREE KINDS OF LUMINESCENT MATERIALS

	FLUORESCENT GLOW DURING EXPOSURE TO ULTRAVIOLET RAYS	PHOSPHORESCENT GLOW AFTER EXPOSURE TO LIGHT OR ULTRAVIOLET RAYS	AUTOLUMINESCENT GLOW FROM SELF-CONTAINED SOURCE
NATURAL FORM	MINERALS: CALCITE, WILLEMITE, FLUORITE	SULPHIDE MINERALS; HUMAN TEETH AND FINGERNAILS	FIREFLY, JELLYFISH, BACTERIA
ARTIFICIAL FORM (POWDER, PLASTIC PAINT OR FABRIC)	FLUORESCENT PAINT	PHOSPHORESCENT PAINT	RADIUM PAINT
DURATION OF USEFUL BRILLIANCE	AS LONG AS UNDER ULTRAVIOLET RAYS	SEVERAL HOURS AFTER BRIEF EXPOSURE TO LIGHT	HUNDREDS OF YEARS
WAR USES	READING MAPS IN THE DARK	SHIPS' DOORS, SAFETY VALVES, STAIRWAYS	CLOTHING MARKER
HOW IT WORKS	EACH ELECTRON MAKES A COMPLETE CIRCUIT TO EXCITED STATE AND BACK 200 TIMES A MINUTE ULTRAVIOLET LIGHT ACTIVATES ELECTRONS EXCITED STATE ORIGINAL STATE	VISCOUS NATURE OF A PHOSPHORESCENT SUBSTANCE DELAYS RETURN OF EACH ELECTRON FOR A PERIOD OF HOURS, SO THAT LIGHT IS EMITTED CONSTANTLY DURING THIS TIME EXCITED STATE ORIGINAL STATE	RADIOACTIVE MATERIALS CONTAIN INTERNAL ACTIVATOR . . . OTHERWISE LIKE FLUORESCENCE EXCITED STATE ORIGINAL STATE

MILITARY USE. A radioactive material sealed in a plastic case has been designed by army engineers to serve as a "taillight" for military vehicles moving through a darkened area. In a complete blackout, the marker can be seen clearly at 100 feet. A similar marker, worn by the leader of a night scouting party, serves to keep the leader in constant view of his men, and prevents the party from becoming separated.

"LIGHTING" DANGER SPOTS IN THE HOME

In an air raid, more damage is likely to result from people bumping into things in the dark than from the bombs. Pasting luminous material on such dangerous spots as pointed desk corners helps to prevent accidents

precautions, New York's Mayor La Guardia uses a car with phosphorescent fenders and bumpers. Many London streets and sidewalks now are outlined with luminous strips or curb markers, which we may possibly adopt in coastal areas.

Fluorescent powders can be used for testing the soundness of a gas mask. They are spread on the outside of the mask, the wearer takes several breaths, and the interior then is examined under black light for telltale glow.

Cases of arson and other forms of sabotage committed with pilfered explosives have been cleared up by injecting traces of fluorescent dye into the waxed-paper wrappings of sticks of dynamite, and the gums and glues that go into bombs. It is impossible to handle them without getting traces of the dye into the pores of the skin. Suspects, rounded up and questioned in a routine way, are then suddenly exposed to black light. The dramatic evidence of glowing hands seldom fails to obtain confessions. Senders of false fire alarms, and passers of counterfeit money, have been trapped by somewhat similar means.

In a standard industrial test for flaws in castings and stampings, the piece is magnetized and dusted with metallic powder, which outlines any cracks or internal defects. A recent improvement on this scheme makes the powder luminous under black light, giving a more conspicuous and sensitive test. The method will also test a surface for freedom from oil.

Medical workers find a new tool in fluorescent stains. Cancerous and other cells treated with these dyes and examined under a microscope with black-light illumination reveal characteristics that can be observed in no other way.

For "blackout parties," originated in raid-darkened London, luminous clothes and furniture provide the only light in the house — except in such games as "blackout golf," played with a self-glowing club, ball, and indoor putting green. Fashion fads include luminous dresses, capes, hats, stockings, hairdress, and jewelry.

More practical domestic uses of modern luminous paint will reduce our yearly toll of 30,000 fatal home accidents. Danger spots such as stair treads and electric fans glow all night when outlined with long-wearing phosphorescent preparations. Applied to street numbers, doorknobs, keyholes, and light switches, they serve a home owner's convenience without using electricity.

Scientists classify luminescent materials into three or more distinct kinds, according to their behavior, which in turn decides which is best suited for a given use.

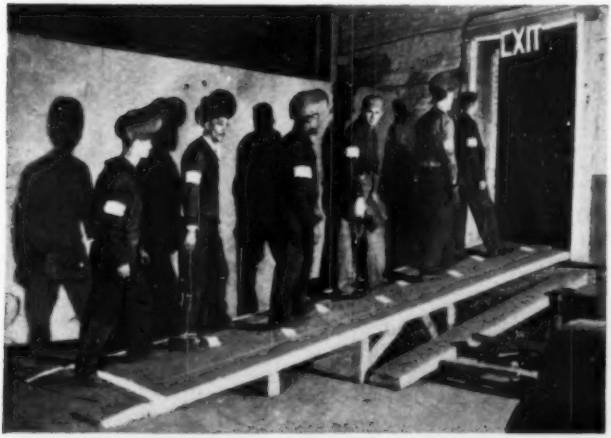
Fluorescent substances glow just so long as they are exposed to ultraviolet rays—popularly known as black light—and no longer. This property has suggested the war use of fluorescent buoys to guide friendly ships through channels in mine fields, when illuminated momentarily by a black-light searchlight. Of the many known fluorescent minerals, some are ores of strategic war metals. Important deposits of tungsten ore have been located by night prospecting with black-light equipment.

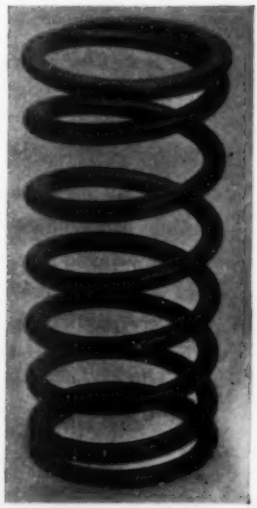
Phosphorescent materials soak up illumination from the sun or from artificial light. Then they proceed to reradiate it for several hours, without exterior stimulation. Luminous paint made from such substances provides all-around service and is unaffected by power failure. One of its former disadvantages—that it could not be extinguished at will—is now reported to have been overcome by Gilbert T. Schmidling, a pioneer American research worker in the field. By illuminating it with strong red light, he says, the phosphorescence can be "put out." Subsequent illumination with sunlight turns it on again.

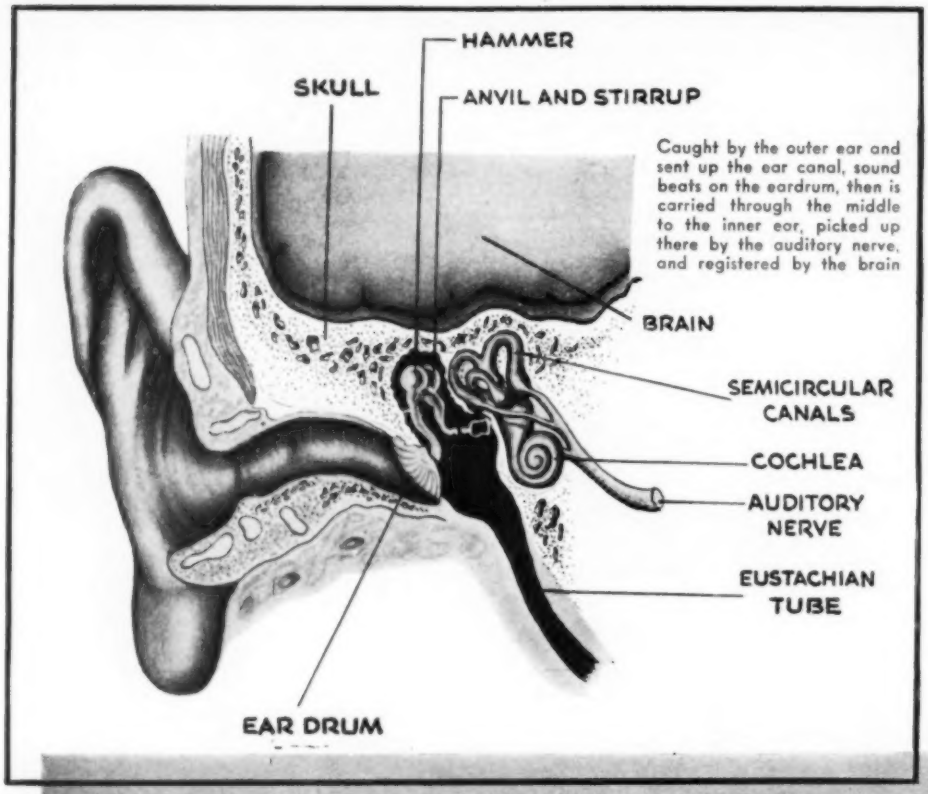
Self-illumination, or autoluminescence, occurs spontaneously from a variety of chemical and physical actions. The firefly, nature's prize example, owes its glow to a slow form of chemical oxidation, which has been duplicated in the laboratory. Crystals of saccharin emit light when crushed or rubbed together. The luminous paint employed on watch dials provides permanent light by bombarding a metallic sulphide with rays from radium.

LUMINOUS MATERIALS HELP INDUSTRY TO "PLAY SAFE"

To protect its workers in the event of a power failure or blackout, a Philadelphia plant has outlined the doorway and ramp shown below with a phosphorescent paint. Note that the workers also wear luminous arm bands. A luminous metallic powder is also being used to detect manufacturing defects. Dusted on the magnetized coil shown at the right, it glows under black light to reveal a flaw down the full length of the coil






HAMMER
SKULL
ANVIL AND STIRRUP
Caught by the outer ear and sent up the ear canal, sound beats on the eardrum, then is carried through the middle to the inner ear, picked up there by the auditory nerve, and registered by the brain
BRAIN
SEMICIRCULAR CANALS
COCHLEA
AUDITORY NERVE
EUSTACHIAN TUBE
EAR DRUM

What do You Know About

Nature gave you a marvelous pair of hearing instruments . . . Modern tests show how they are best protected and used.

Drawings by JOHN GILMORE

SAY "Good morning" to the first 15 people you meet, and at least one of them probably will have to guess at what you said. Or, if all of them hear you clearly, *you* may be the one in 15 who has defective hearing. That, according to a recent estimate made by the New York League for the Hard of Hearing, is the average ratio of deafness, whole or partial, in the United States. Some people are born deaf, but most defective hearing is acquired as a result of disease, injury, or neglect. Economic as well as personal and social problems are a result; more than 40 percent of those with acquired deafness have had to change their occupations.

Fundamentally, the human ear is a simple mechanism and shouldn't be hard to take care of. It is a funnel which catches sound waves, converts them into nervous impulses, and sends them to the brain to be sorted out and classified. Man has taken the same basic principles and made the relatively simple telephone transmitter, which catches sound waves and converts them into fluctuating electrical impulses. In detail, however, the ear is a complicated set of physical gadgets, like most of nature's machines.

There are three major parts: the outer ear, the funnel which catches the sound; the middle ear, which transmits the sound; and the inner ear, where the auditory nerve picks up the vibrations and sends them along to the brain. The middle and inner ears are the most complicated, the most easily injured, and the hardest to repair.

The outer ear consists of the familiar flap of cartilage sometimes called the "shell," and the auditory canal which extends inward to the eardrum. The eardrum is a membrane that stretches across the auditory canal and separates the outer from the middle ear. Another name for the eardrum is the tympanic membrane, and it acts like the head of a drum, vibrating when sound waves strike it as a drumhead vibrates under a drumstick.

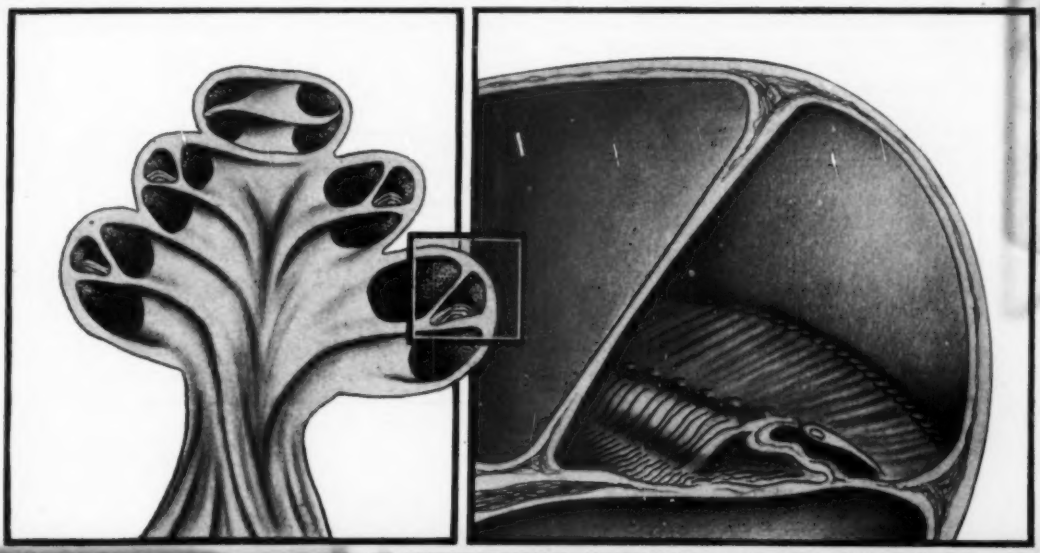
On the far side of the eardrum, in the middle ear, are three small bones called ossicles. The "hammer" rests on the eardrum and responds to the sound vibrations, which it in turn taps out on the "anvil." The "anvil" passes them along to the "stirrup," which fits into an opening in the inner ear and touches the cochlea, the apparatus which changes sound vibrations into nervous impulses.

The cochlea is a tiny organ, coiled like a snail shell and filled with a thick fluid. On its inner walls are sensitive, hairlike terminals of the auditory nerve. When the sound waves are tapped out on one end of the cochlea by the "stirrup" bone, the fluid inside is set to vibrating, the nerve terminals are agitated, and the message is started along the auditory nerve toward the brain.

The cavity of the inner ear, where the cochlea lies, is in one of the hardest bones in the body, a fact important in the use of one type of hearing aid. Also in that cavity are the "balancers," three little tubes coiled into connected semicircles and set at right angles to each other so that they look something like a distorted pretzel. They have nothing to do with the sense of hearing; they are the center of the sense of equilibrium—the body's leveling instrument. Head colds and ear infections sometimes disturb them and cause dizzy spells. When a cold affects the sense of hearing, it is because the Eustachian tube, which connects the middle ear with the throat, is swollen partly shut. The Eustachian tube's function is to equalize the air pressure on the two sides of the eardrum.

A serious infection in the aural passage, or even the rupturing of the eardrum, can be caused by sticking a match stick, hairpin, or the corner of a towel into the ear to re-

Your Ears?



Below, left, is seen a cross section of the cochlea, the receiving instrument of the inner ear. The fluid with which the canals are filled is set in motion by sound waves. At right, an enlarged view of one section of a canal. The hairlike antennae of the auditory nerve pick up the vibrations of the fluid and transmit them to the brain. In the lining of the cochlea there are said to be more than 23,000 tiny nerve cells

move water, wax, insects, or other foreign matter. In such cases only a few drops of warm oil should be used. If that doesn't remove the object, then a physician should be consulted promptly.

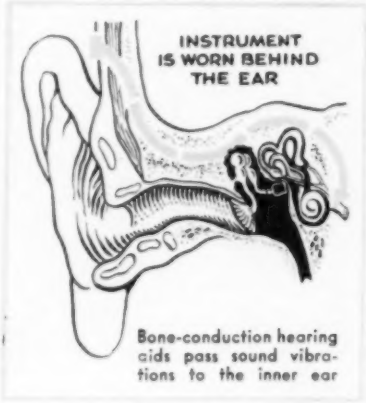
Treatment of impaired hearing is in many cases both simple and effective. Far more trouble is caused by refusing to admit that one's hearing is not up to par, or by trying to conceal the fact, than by poor hearing itself. The person who tries to answer a question or follow an order only half heard may say or do something inexcusably stupid in the attempt to "cover up." More jobs are lost by trying to conceal poor hearing than by the difficulty itself.

Thanks to scientific research, partial deafness can now be repaired almost as easily as nearsightedness. The chief problem is to find the trouble—and to get the patient to acknowledge it to himself.

Tests in schools have been especially effective in spotting deafness at a time when medical aid can be of particular help. Many children who seem to be backward or stupid are found to be only hard of hearing, and treatment often brings them up to par in their studies.

The old-fashioned hearing tests, based on voice tones or the tick of a watch, served in their day but gave no accurate measure of the degree of deafness or the reason for it. Now the audiometer is used, an instrument which Dr. Fred W. Kranz, physicist and research director of the Sonotone Corporation, calls the first accurate device for measuring hearing. With the audiometer, standards of normal hearing have been established, and tests with it show not only the degree of hearing loss in any individual but whether the source of the affliction is in the middle or the inner ear.

Once the source and degree of deafness are ascertained, various kinds of hearing aids can be prescribed. The Sonotone Research Laboratories, for instance, have developed two types of electrical hearing aids, one for air conduction, the other for bone conduction. Both work on the same principle as the telephone: the transmitter picks up the sound waves, changes them to electrical impulses, and sends them to a receiver which changes them back to sound waves or vibrations where the defective ear can best make use of them. The air-conduction type of hearing aid sends the receiver's sounds directly into the ear passage. The bone-conduction type, which is worn behind the ear rather than in it, sends sound vibrations through the bone directly to the cochlea in the inner ear.



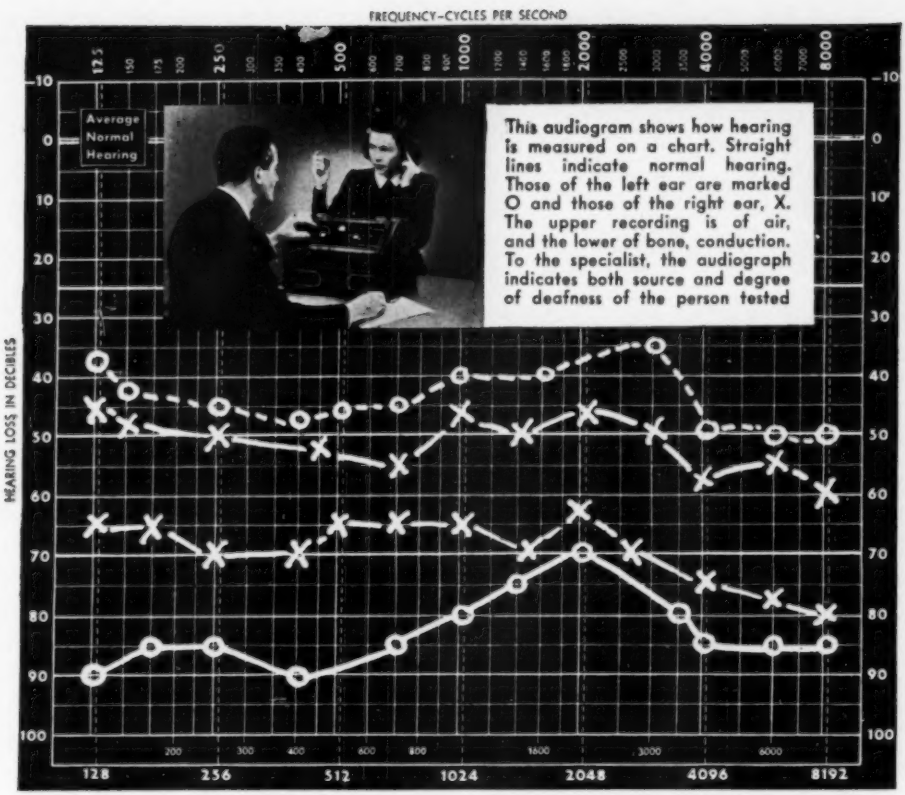
Bone-conduction hearing aids pass sound vibrations to the inner ear

Recently, radio principles have been adapted for use in hearing aids. The transmitter in this type of instrument uses a Rochelle crystal instead of carbon grains. When the crystal is activated by the vibration of a diaphragm, the strength of the electrical current through the crystal is varied and the sound waves are converted into electrical impulses. Miniature vacuum tubes are used for amplification in the receiver. The result is very different, both in appearance and effectiveness, from the ear trumpet of grandfather's day.

With all these advances in understanding and treatment of hearing defects, there is seldom any excuse for a person who suffers from partial deafness. In the first place, you should know enough about your hearing equipment to give it reasonable care. If it fails naturally, give it scientific aid.

Helpful Earful

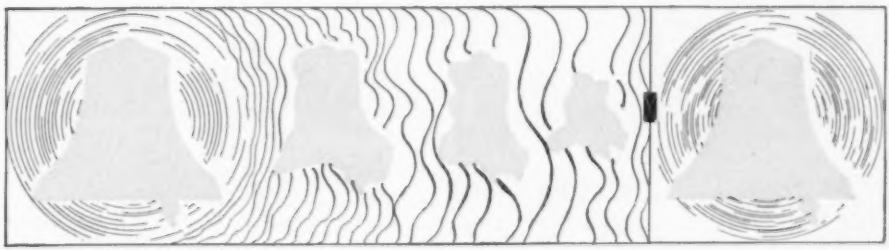
NEVER box a child's ears, or hit him on the side of the head.
NEVER try to remove objects that a child has put into his ear. Take him to a physician.
NEVER clean the ears with a hard or pointed object.
NEVER dry water-filled ears with a towel. Tilt the head and let them drain.
NEVER fish for an insect that has got into the ear. Go to a physician or pour ear drops or warm oil into ear until insect drains out.



THIS SHOE SHOULD FIT

Even to the partly deaf, some sounds are distorted and unintelligible, while others are wholly unheard. The diagram above shows how unevenly a typical sentence is heard by a deafened ear

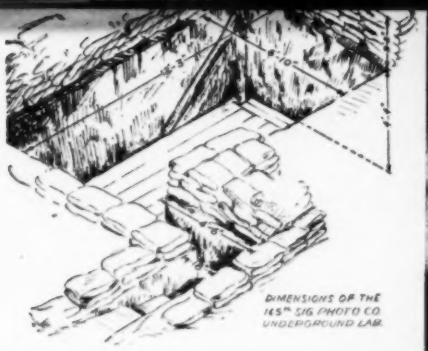
Below, two important functions of hearing aids are shown: distorted frequency waves must be corrected for clearness, and every sound must be amplified to suit the requirements of the user



HOW 10 TONS OF BOMBS can be carried by a Flying Fortress is shown strikingly in this view of one of the big Boeing bombers on a practice flight near Mount Rainier in the State of Washington. Outside racks with forklike fingers hold the extra bombs on the bottom of the fuselage near the landing wheels. This supplementary arrangement permits the carrying of an unusually heavy load for limited-range operations.

SHREDDED AND NEATLY BALED in 200-pound packages, tin cans, automobile bodies, old stoves, and all kinds of scrap iron are made ready for reprocessing in a huge machine devised by Clarence M. Gregg, president of the Los Angeles By-Products Company. Chrome molybdenum hammers or cutters on the outside of a drum revolve at 1,800 r.p.m. to break up the pieces into tiny bits, which ride through a magnetic separator that deposits dirt and nonferrous metal in one bin and iron in another. Automatic balers then bind the iron scrap into bales of uniform density.

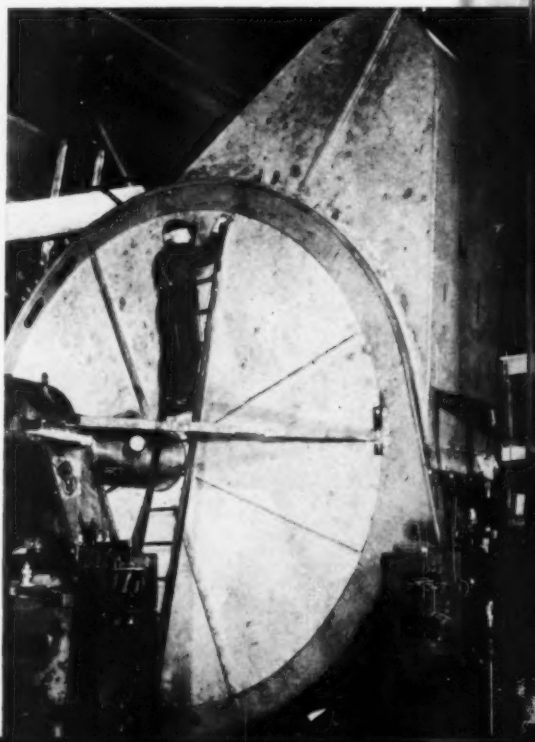
Scrap is fed into this giant machine on a conveyor, goes into a five-ton shredder, and comes out in neat bales

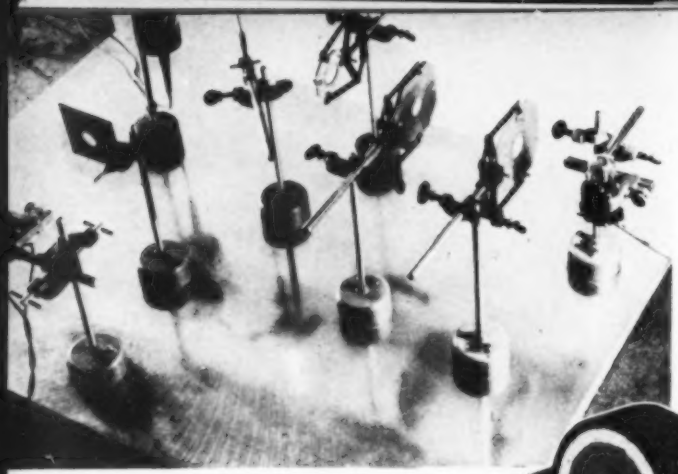


A BOMBPROOF LABORATORY for processing photographic material at the front has been designed by the 165th Signal Photographic Company at Fort Sam Houston, Tex. As shown in the drawing by military artist Swanlund, the underground darkroom provides a working space of about six by 12 feet and is entered through a protective right-angle passageway. One of its features is a ceiling rack in which a camera can be placed, as demonstrated by Sergeant Smoody in the photograph above, for use in making enlargements. Heavy sandbagging guards against damage by bombs and shells, so that work can be carried on under fire.

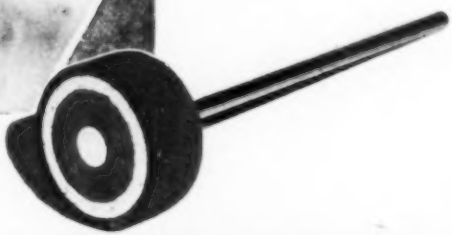
LANDING GEARS that stick need no longer threaten pilots or their planes. Engineers of Walter Kidde & Co. have developed a carbon-dioxide power unit which, in an emergency, can be used to lower landing gear or open and close bomb-bay doors. Because of the high compression of carbon dioxide, a two-pound cylinder is sufficient to operate even the heaviest equipment.

GIANT ENCLOSED MOTORS, such as the one shown below, are being built by General Electric for tankers of the U. S. Maritime Commission. Each motor has a sheet-iron cover as a protection against dirt, and is equipped with an air-recirculation system. Cool air entering at the bottom of the motor rises as it becomes heated and is then piped off into a cooling blower, which carries it back to the bottom of the motor.



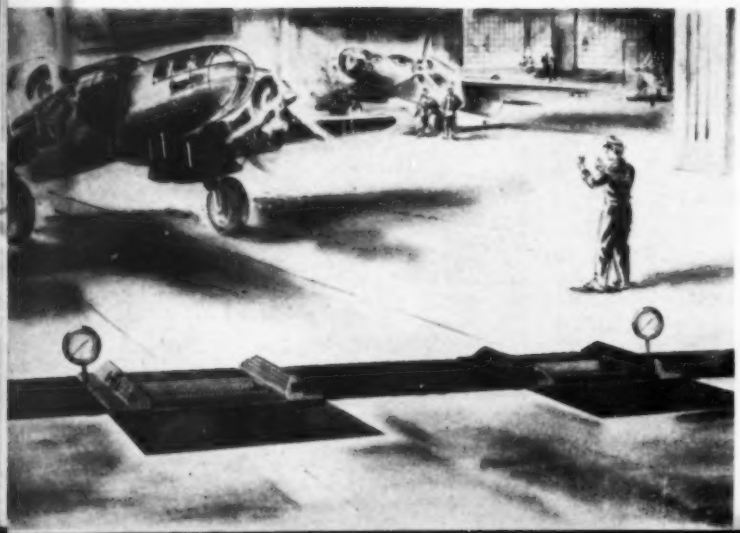


ALNICO MAGNETS set in the bases of the standards are simplifying the setting up of experimental optical systems. Adhering to a metal table top or wall, the magnets hold the system in position and prevent any disarrangement even when adjustments are made. This use of alnico was devised by Norman Barnes of General Electric.



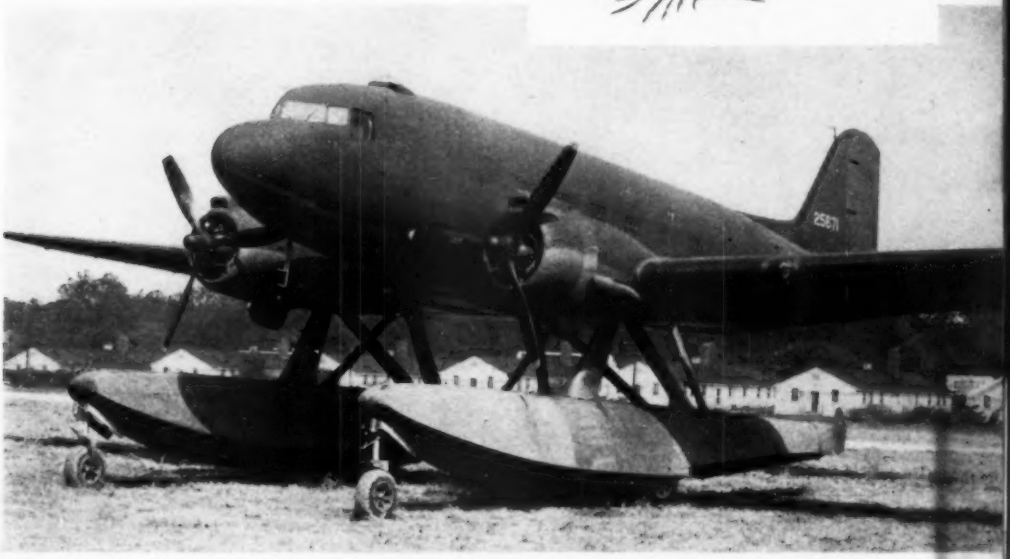
Although standards will adhere firmly to any steel surface, they can be easily moved when necessary. At right, a bottom view of a standard, showing an alnico magnet set in its base

NEW GASOLINE OVENS are being used by the U. S. Army Quartermaster Corps for baking in the field. Shown at right are eight of these two-chamber ovens, which can do the baking for 10,000 men. Tended by a bakery platoon of 36 men, and using 3,600 pounds of flour, this battery of ovens can turn out 5,000 pounds of bread in 24 hours. Below: fire-control units.



A BRAKE TESTER for airplanes has been developed by the Safety Equipment Co., of South Bend, Ind. The device cradles the plane's rubber tires between rollers that provide traction equal to that of dry concrete. When the brakes are applied, the force needed to turn the wheels is registered on a dial, which gauges the braking action.

AMPHIBIOUS FLOATS, attached experimentally to the Army Air Forces' C-47, may make this big cargo transport an efficient seaplane as well as a land plane. Tried out at Wright Field, Dayton, Ohio, the new floats enabled the plane to alight on water, taxi to shore, and climb on land under its own power. This may prove particularly useful in rescues of flyers on coral reefs in the Pacific. Further experimentation is being carried out by the AAF in the design and use of the floats.



RUBBER-CLEATED SOLES AND HEELS are being put on ski boots for our soldiers, who may be using them soon to cross the Alps for a closer crack at Hitler. Replacing the steel cleats and leather worn by mountain troops in World War I, this footwear was developed by Adams Carter, famous mountain climber and now a research specialist for the Quartermaster General, and experts of the Goodyear Tire & Rubber Company. The design, an improvement on a Swiss-Italian shoe, is light, warm, waterproof, and silent on flinty surfaces.

CLEAR PLASTIC DOMES are being mounted on open antiaircraft observation posts along the Atlantic seaboard to keep sky watchers dry and comfortable. Built of Lumarith, made by the Cellanese Celluloid Corporation, of New York, the domes offer shelter from rain, sleet, and snow without cutting visibility, and also improve communication by screening out noise.

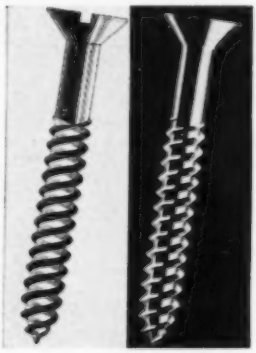
Hauling a landing barge ashore on Attu with the help of a tractor and an odd but efficient movable dry dock called a "geeheebee"

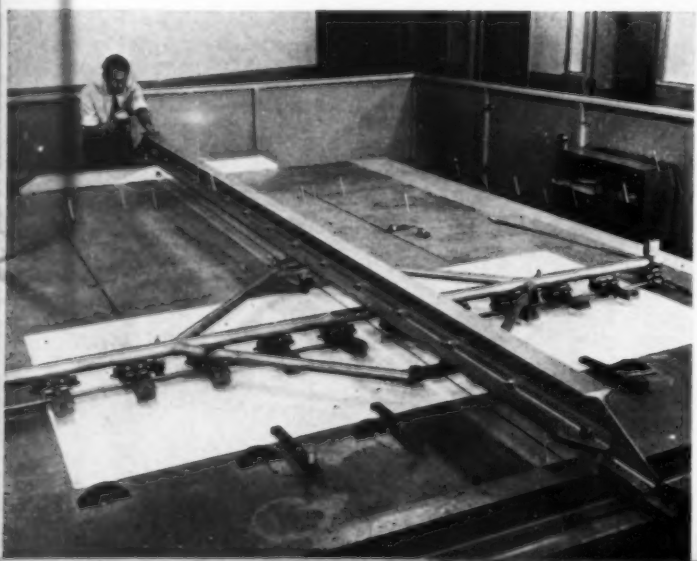
"GEEHEEBEE" is the name that U. S. soldiers and sailors have given to the odd contraption shown at the left. Much in evidence where amphibious operations are in progress, it performs yeoman service when repairs or repainting must be done on the landing barges and other small invasion craft.

The "geeheebee" is backed by a tractor into the surf until it settles over a landing boat or other small craft, which is then chained to the frame. As the tractor pulls the two ashore, the boat is lifted clear of the ground. After repairs have been completed, the procedure is reversed to relaunch the craft. Empty oil drums on the "geeheebee" permit it to be floated ashore from a transport or other large vessel.

PLASTIC EAR STOPPERS are now molded from Plexiglas to fit the ear canal. Designed by Arthur F. Farman, an employee at McClellan Field in California, they are manufactured by Rohm & Haas Company, of Philadelphia, Pa.

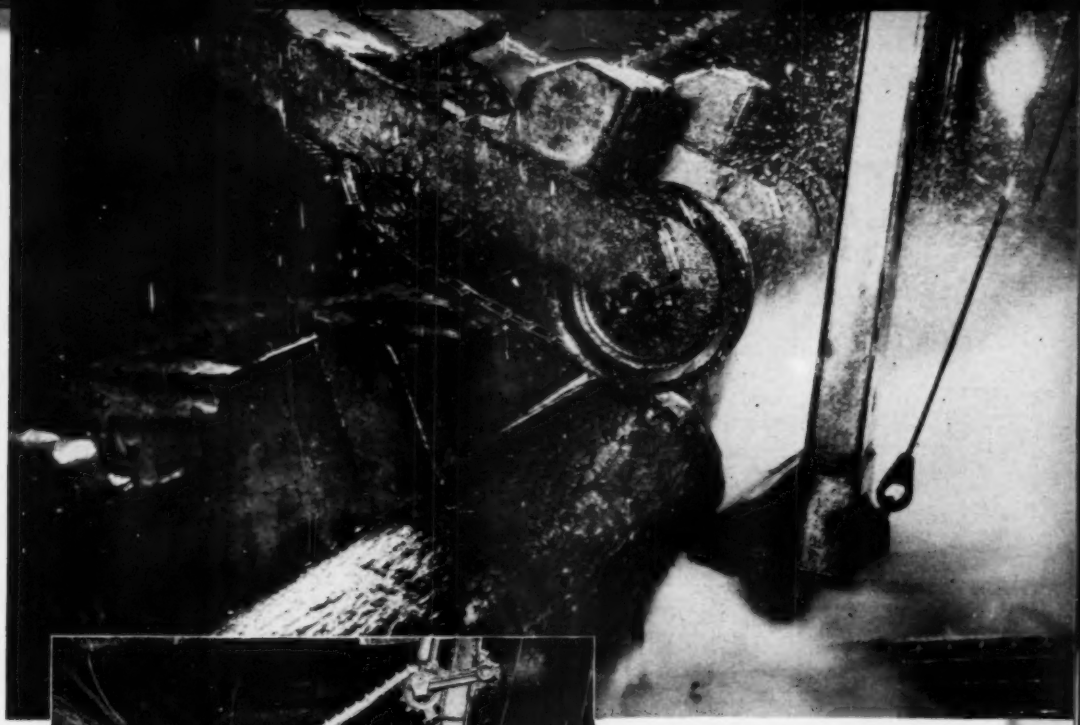
TWIN THREADS are a new idea for screws for wood, plastic, and combination assemblies. These screws, made by the Blake & Johnson Company, of Waterville, Conn., have straight sides, relieved shank diameter, and a single balanced point.

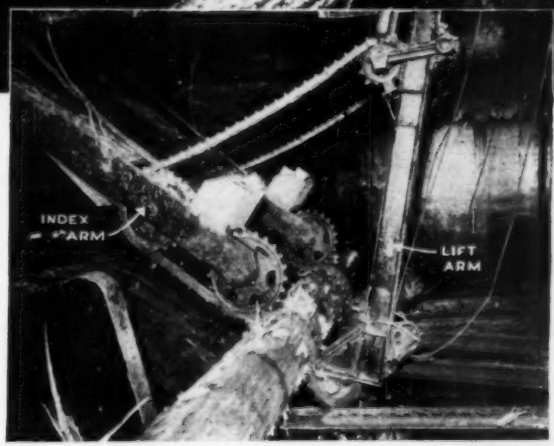




TWO MEN OPERATING this grid machine, developed by Lyle F. Pierce, chief of master layouts at the Boeing plant in Seattle, can make in one day a crosshatched background for full-scale mechanical drawings that once took six months. The machine scribes simultaneously 12 parallel lines 100 inches long and accurate to .005 inch.

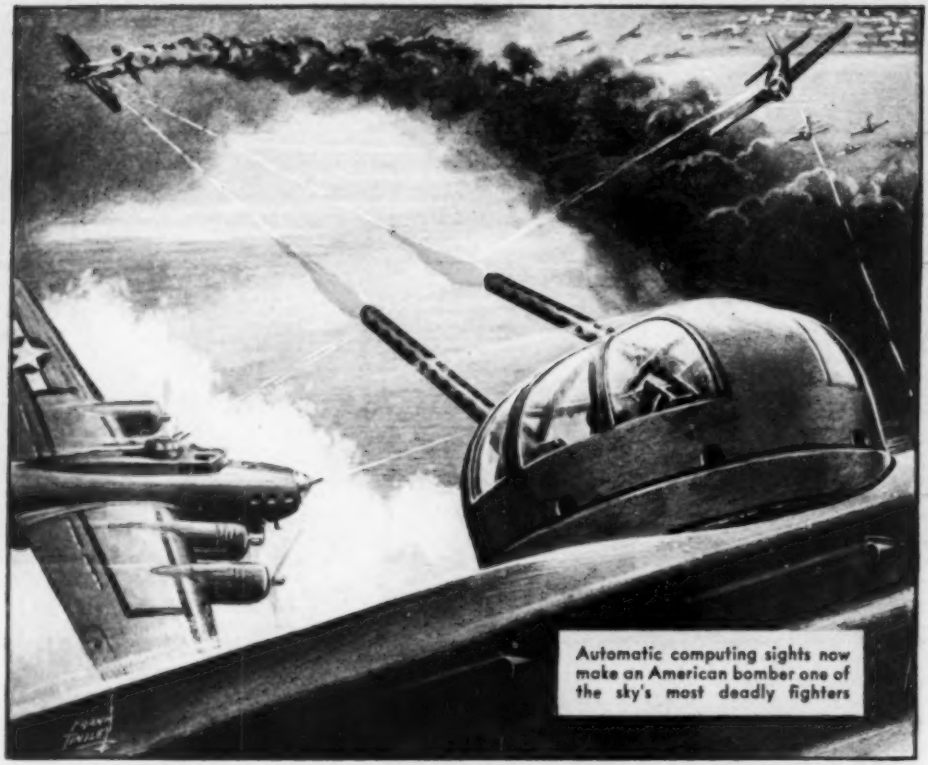
Backgrounds thus made on painted steel are joined together, sometimes into sheets 20 by 30 feet, for bases on which full-size drawings are put for parts of Boeing planes.





WATER JETS that can peel the bark off giant logs more swiftly than knives are the basis of a hydraulic barking machine developed by the Weyerhaeuser Timber Co. of Everett, Wash. Twin nozzles on a moving carriage force streams of water up against a rotating log at a pressure of 14,000 pounds per square inch, producing erosion of bark and cambium. Steel arms steady the log. Six-foot trunks can be stripped in a few seconds.

"STICKY" BOMBS that are thrown by hand and glue themselves against their targets have now been revealed as one of the "secret weapons" the British Eighth Army used so successfully in the African campaign. The bomb consists primarily of a glass flask fitted with a short handle and filled with an explosive. Wrapped around the flask is a tight-fitting woolen jacket that has been treated with a special adhesive. When hurled against a tank, the bomb fastens itself there leechlike until it explodes. For protection before it is used, the bomb is fitted with a hinged metal casing held together by a narrow metal band wrapped around the neck of the bomb, as shown at the right.



Automatic computing sights now make an American bomber one of the sky's most deadly fighters

Why our aerial gunners are

Outshooting the Axis

By HAL BORLAND
Drawings by FRANK TINSLEY

AMERICA'S big bombers, which roared to fame as tough ships that could "lay eggs in a basket" from 20,000 feet and take terrific punishment, are even more famous now as killers of the sky. On one bombing mission, not long ago, a flight of them knocked out 74 Nazi fighters. Good to begin with, they are now superbly lethal.

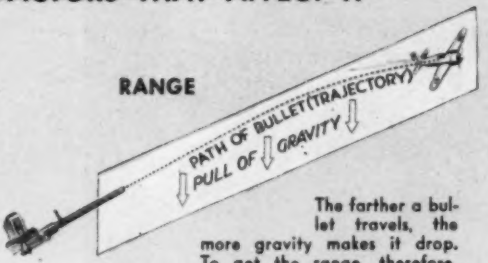
How come? The answer is gunnery—gunnery that is more than weapons, more than power turrets, more than competent gunners. It is all these, plus an automatic computing gunsight that makes supermen of the bombers' gun crews. This automatic sight has given our big ships a fire-power "reach" of more than 1,000 yards, or twice the effective range of Axis aerial guns.

Until recently this automatic sight was a secret weapon. Its details are still secret, but the veil has been lifted enough to show what it can do and, in general, how it does it. Basically, it is a compact machine that automatically calculates speed, drift, windage, trajectory, and range, and compensates for all these factors as it aims the guns where the bullets will do the most damage to an enemy plane. It does all this with a minimum of human effort, and reduces human error to a minor factor by eliminating virtually all guesswork. And, lastly, it is so simple to operate that three weeks' training with it can make an expert gunner out of a novice.

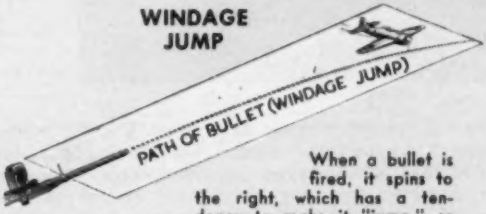
LEAD—AND THE VARIOUS FACTORS THAT AFFECT IT

POSITION OF DUCK WHEN SHOT REACHES RANGE
LEAD
POSITION OF DUCK WHEN GUN IS FIRED
SHOT'S LINE OF FLIGHT
GUN SHOULD BE AIMED ALONG THIS LINE

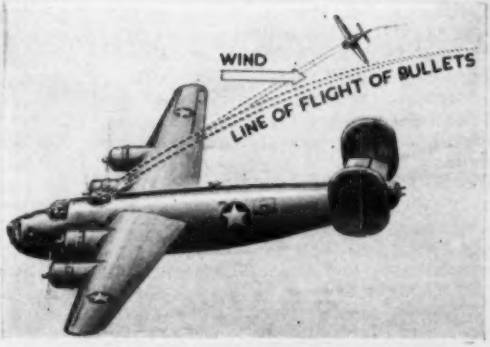
LEADING consists of aiming ahead of a moving target so that the bullet and target will arrive at the same point simultaneously. In sketch above, the hunter will miss his target because the duck will have moved ahead during the flight of the bullet



The farther a bullet travels, the more gravity makes it drop. To get the range, therefore, gun muzzle must be elevated



When a bullet is fired, it spins to the right, which has a tendency to make it "jump," or veer off, in that direction



WINDAGE. As the bullets leave the plane's guns, the wind rushing past the plane has a tendency to deflect them toward the tail. The degree to which this force of wind will change the direction of the bullets' flight is determined by the speed at which the airplane is flying

Any duck hunter or trapshooter has a rough idea of the primary problems of an aerial gunner. First of all, to hit a moving target he must "lead" it, that is, shoot far enough ahead of it to allow for its speed. Then he must take into account the range of his gun, the effect of the wind, and the characteristics of the shell he is shooting.

The duck hunter's target, however, seldom flies more than 60 miles an hour. The aerial gunner's target travels more than six times as fast. And while the duck hunter shoots from a stationary position, the aerial gunner is in a bucking, twisting ship traveling at least 200 miles an hour. The duck hunter uses a shell whose hundreds of tiny pellets are deadly over a three-foot circle at 50 yards. The aerial gunner's weapon fires only one bullet at a time. To approximate the aerial gunner's task, the duck hunter would have to do his wing shooting with an automatic rifle while sitting in the rumble seat of a car going down a country road at 50 miles an hour. Accurate shooting from a big bomber with manually operated weapons and ordinary sights is phenomenal. Man simply is not physically equipped to do it.

Of his equipment, his eyes are probably nearest to the necessary perfection. When a bomber is flying at 200 miles an hour and an oncoming pursuit ship is moving at 400 miles an hour, the combined speed of approach is 300 yards a second, which is not

SIGHT AND TURRET. At the left, an officer carefully examines one of the automatic computing sights before it is installed between a turret's two guns. Above, a gunner grins as he crawls into the belly turret of a big bomber

very far from the speed of sound. Yet a gunner's eye can follow a pursuit ship traveling at that terrific speed. In a wink of the eye, however, the target will have moved about 25 yards. And we know from optical research that persistence of vision makes the eye incapable of registering an abrupt change lasting less than 1/32 of a second. The eye is fallible to a degree not yet fully determined; but, on the whole, it is good enough for the aerial gunner's job.

A man's physical reflexes are less dependable. But because of their importance, the Air Forces insist on high standards. Impulses from the eye or ear must be obeyed by the muscles without perceptible delay. Tests of thousands of automobile drivers have shown an average reaction lag of .44 second. Yet in half that time an aerial gunner's target may move as much as 66 yards. A trigger finger even a tenth of a second late in obeying the eye's order to fire would put the burst of fire completely off the target, even if no other factors were involved.

Mental processes are another factor. The best mathematical mind isn't fast enough to solve, at a given instant, a problem dealing with air speeds of hundreds of yards a second, particularly when such complex matters as windage, drift, trajectory, and range are also involved. That is why the guns in a fighter plane are in fixed mounts; they can be aimed by pointing the plane itself, and no complicated calculations are necessary.

Add to the gunner's problems the fact that high altitudes slow up both physical reflexes and mental processes, and then the situation becomes really complicated. Oxygen helps to compensate for the altitude, but low temperatures—it gets down as far as 45 below zero F. at 25,000 to 30,000 feet—also tend to retard the reflexes.

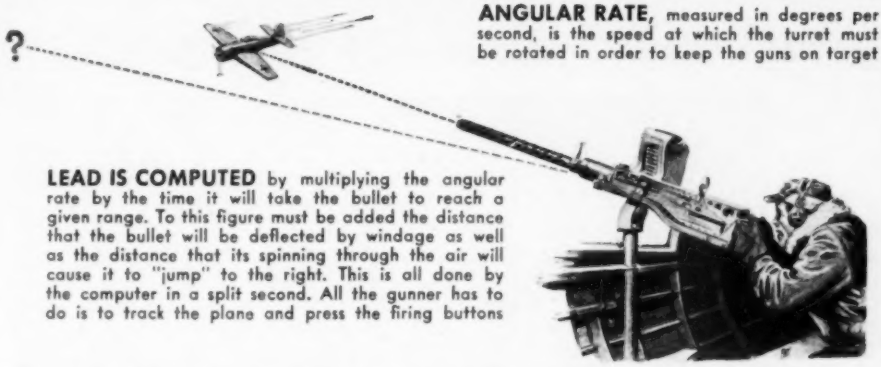
The automatic computing sight was developed to minimize all these human factors. It is a mechanical Einstein that literally computes half a dozen complex and constantly changing problems, and delivers the correct answer at any desired instant. Although the gunner sights at the target itself, the computer aims the guns at the point where the target will be when they go into action.

Typical of several models is the sight developed by the Sperry Gyroscope Company for use with a hydraulically driven turret. Looking like an ordinary small black box, it is mounted between the turret's two guns. At one end of the box are knobs similar to the tuning knobs on a radio. On its top is a reflecting glass—the scanning sight—with two parallel lines of light which can be spread apart or drawn together by manual control or a foot pedal. These light lines are the governors of the range finder.

Before the take-off, the computer is set for the type of ammunition used and windage jump, or deflection to the right caused by the spin of the bullet. After the take-off, another adjustment is made to compensate for the plane's speed. A power switch takes the manual labor out of the gunner's job by making the turret swing automatically in accordance with the "orders" from the sight.

The gunner has a pair of handle bars with firing buttons at his finger tips. When he spots an enemy plane approaching, he identifies it by type and sets a master knob on the sight at the plane's approximate wing spread. A Messerschmitt, for example, with a wing spread of about 33 feet, will call for a setting at that figure. Swinging the turret until the oncoming target is framed in his reflecting glass, the gunner brings the light lines to their minimum spread, which is governed by the master knob setting when he identified the enemy plane. Since

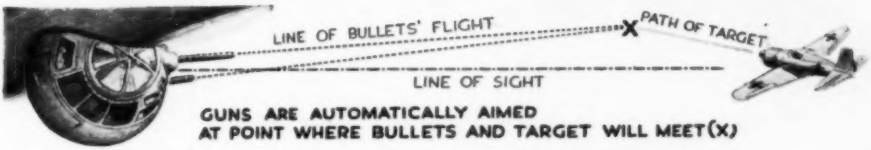
HOW SIGHT DOES WHAT NO HUMAN MIND CAN



ANGULAR RATE, measured in degrees per second, is the speed at which the turret must be rotated in order to keep the guns on target

LEAD IS COMPUTED by multiplying the angular rate by the time it will take the bullet to reach a given range. To this figure must be added the distance that the bullet will be deflected by windage as well as the distance that its spinning through the air will cause it to "jump" to the right. This is all done by the computer in a split second. All the gunner has to do is to track the plane and press the firing buttons

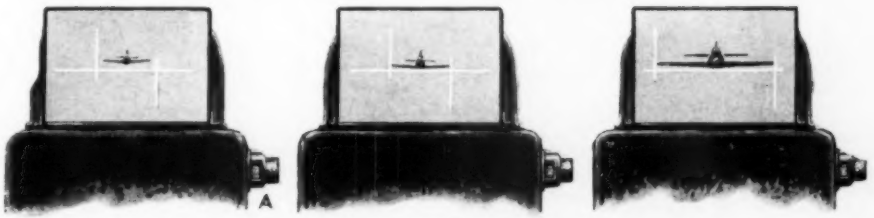
HOW COMPUTER GETS THE INFORMATION THAT IT NEEDS



GUNS ARE AUTOMATICALLY AIMED AT POINT WHERE BULLETS AND TARGET WILL MEET(X)

The speed at which gunner rotates turret in order to track plane gives automatic gunsight angular rate. Distance of plane (see below) gives sight the time of bullet's flight. With correction previously set for windage and "jump," gunsight now has all information necessary for computing lead

SCANNING SIGHT TELLS THE DISTANCE OF ENEMY PLANE



1 As soon as he identifies the enemy plane, the gunner sets the master knob for the plane's approximate wing spread. He then brings the reticules as close together as setting will allow

2 When the approaching plane fills the space between the lines, the gunner knows that it is within effective range, and that he can start tracking and pressing his firing buttons

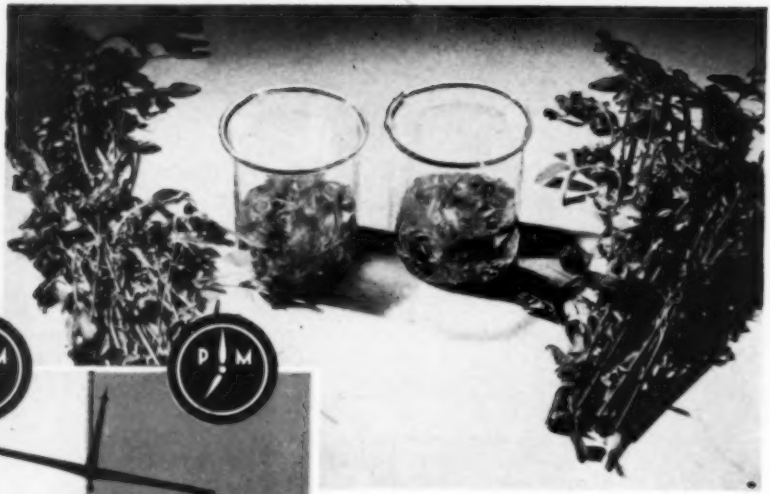
3 As the plane grows larger in the sight, the gunner moves the lines apart so that they always just enclose the plane. In this way he keeps gunsight "informed" of the plane's distance

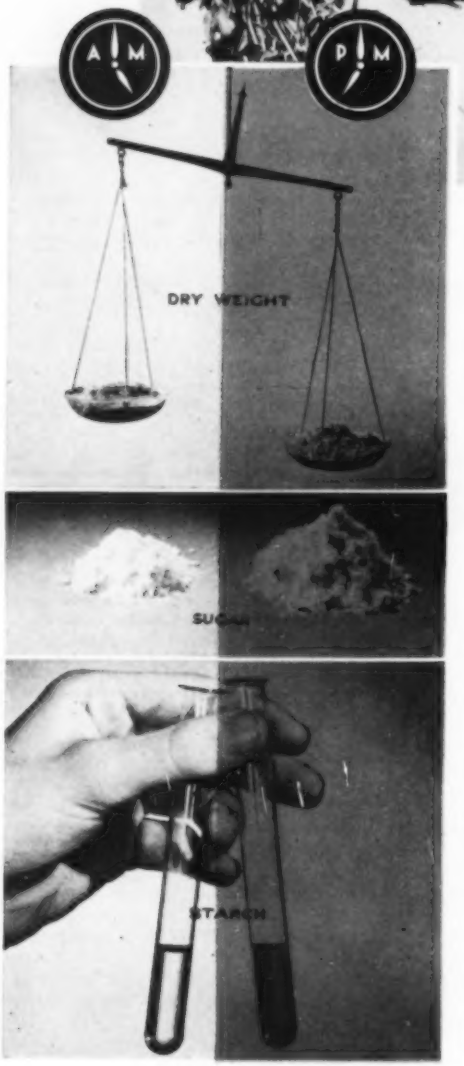
the over-all dimensions of a fighter are approximately the same from any angle, he has only to keep the plane between the light lines, and as soon as the target fills the space between the lines it is within range. At that point, the gunner can begin effective fire, and can continue it as long as the light lines enclose the approaching plane's extremities.

Everything has been compensated for automatically—range, speed, windage, deflection, and angular rate. All he has to do is track the plane, and press the firing buttons.

All American medium and heavy bombers are now equipped with automatic computing sights and power turrets of one type or another. This accounts for the lopsided scores when bombers go out and run into fighter opposition. Neither the Japs nor the Germans have power turrets or computing sights, and, considering the development necessary to bring them to perfection and the precision work needed to manufacture them, it is unlikely that the Axis will produce such a sight unless the war drags on considerably longer than now seems likely.

Make Hay While the Sun SETS!





Alfalfa cut in morning and late afternoon shows little difference until it undergoes chemical tests. Then the afternoon-cut fodder is found to contain more dry weight, sugar, and starch

FARMERS who cut alfalfa, grass, and corn in the late afternoon instead of in the early morning may be storing in barns and silos hundreds of pounds more actual starch and sugars for their livestock. This is the conclusion of Prof. O. F. Curtis, of the New York State College of Agriculture, Cornell University, who is supervising the study of the food contents of forage crops cut at different times of the day. According to these tests, the carbohydrate content is lowest in the early morning and reaches its peak in late afternoon.

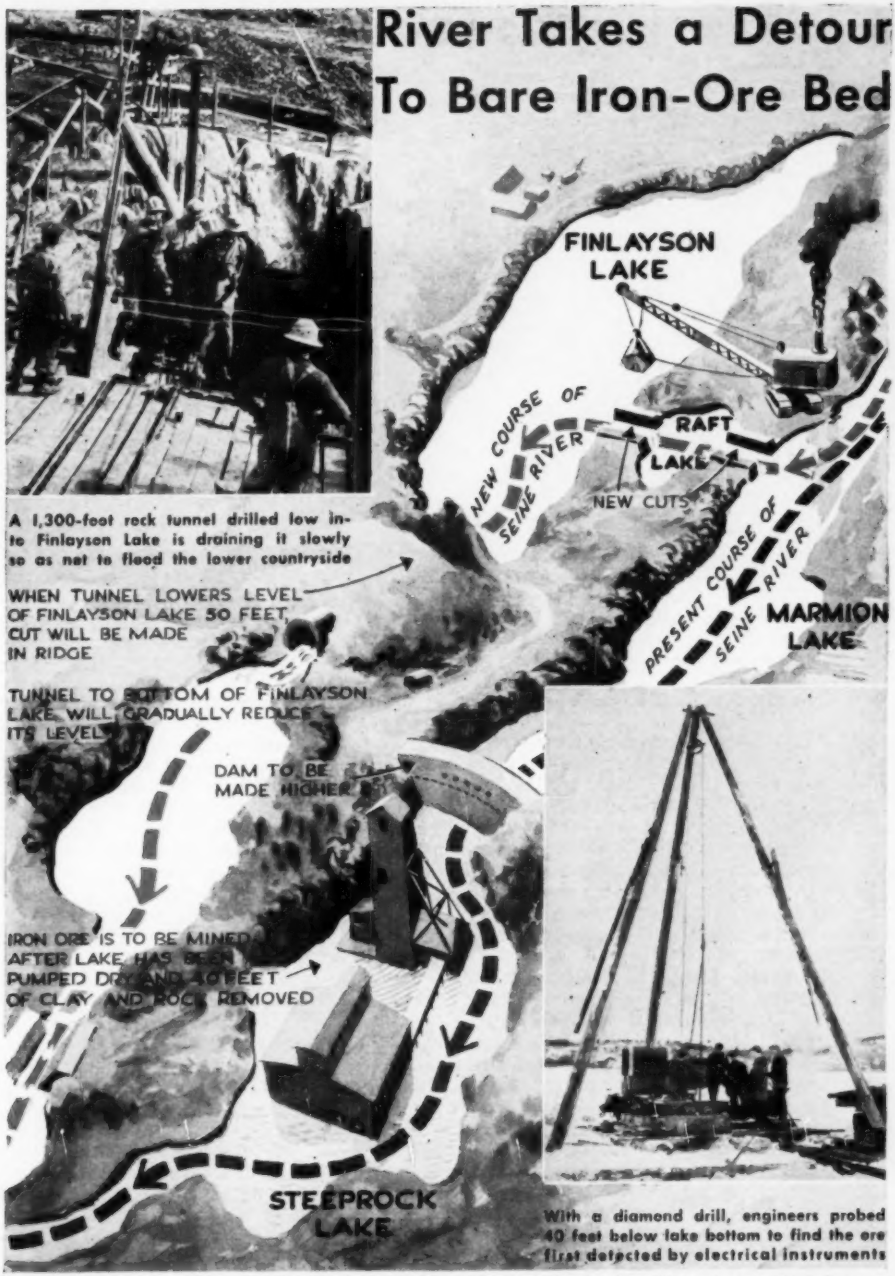
Tests with alfalfa showed that late-afternoon cutting produced an average of 90 pounds, or 90 percent, more starch and sugar to the acre, and 500 pounds, or 20 percent, more dry matter, than plots harvested in the morning. Afternoon-cut grass gained 50 percent more sugar.

By photosynthesis, a miracle of transformation not yet clearly understood, green plants take carbon dioxide from the air and water from the soil and, under the action of sunlight, change them into starch and sugar. This has long been known, but it is a revelation that such a great proportion of starch and sugar is lost during the night, apparently consumed in respiration and changed into cellulose.—KENNETH M. SWEZEY.

POPULAR SCIENCE

River Takes a Detour To Bare Iron-Ore Bed

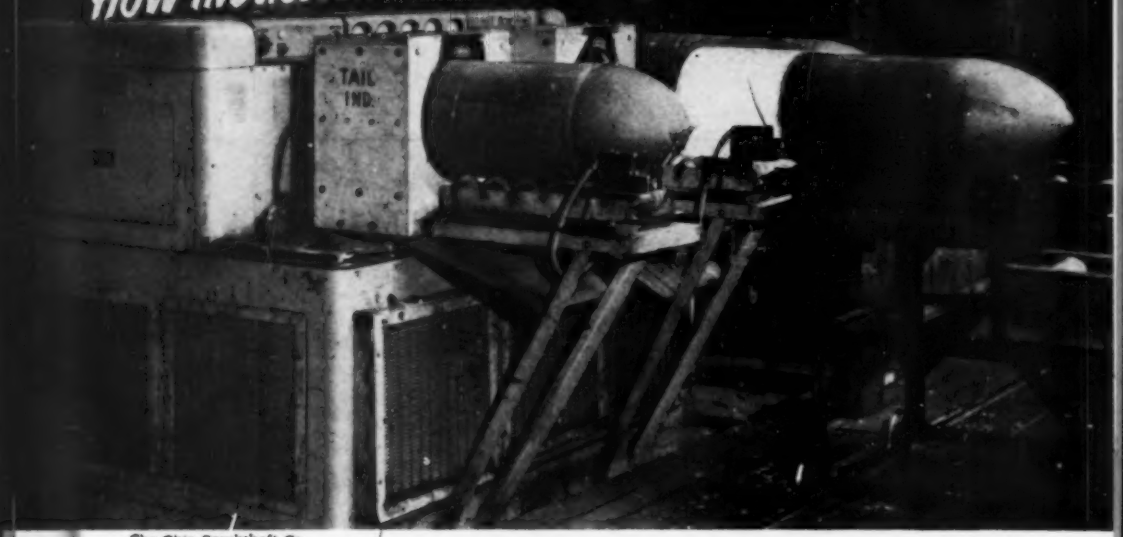
A 1,300-foot rock tunnel drilled low into Finlayson Lake is draining it slowly so as not to flood the lower countryside


FINLAYSON LAKE
NEW COURSE OF SEINE RIVER
RAFT LAKE
NEW CUTS
PRESENT COURSE OF SEINE RIVER
MARMION LAKE
WHEN TUNNEL LOWERS LEVEL OF FINLAYSON LAKE 50 FEET, CUT WILL BE MADE IN RIDGE
TUNNEL TO BOTTOM OF FINLAYSON LAKE WILL GRADUALLY REDUCE ITS LEVEL
DAM TO BE MADE HIGHER
IRON ORE IS TO BE MINED AFTER LAKE HAS BEEN PUMPED DRY AND 40 FEET OF CLAY AND ROCK REMOVED
STEEPROCK LAKE

With a diamond drill, engineers probed 40 feet below lake bottom to find the ore first detected by electrical instruments

BIGGEST drainage job in North American mining history is uncovering iron-ore deposits under Canada's Steeprock Lake, into which flows the Seine River. By raising the dam at the lake's inlet, making cuts between the higher Marmion and Finlayson lakes, and opening a drain tunnel into the bottom of the latter, the Seine has been directed into a new course. Pumps are now emptying Steeprock Lake.

HOW INDUCTION FURNACES ARE MAKING IT



The Ohio Crankshaft Co.

These 500-pound-bomb casings are being induction-heated prior to the process of tail spinning. Note the absence of handling tongs, made possible by the unusual localization in this type of heating. The ends of these casings can be heated to 2,000 degrees F. in just about three minutes and 15 seconds

By JACK O'BRINE

WAR industry is "cooking" with electricity these days. At almost any plant where the application of heat enters into metal processing, you'll find an induction furnace doing the job. Its magic coil is taking the place of fire to produce record-breaking quantities of fighting equipment. Improved cannon, armor-piercing shells, parts for tanks, planes, and submarines, and a great miscellany of war tools come magically from it.

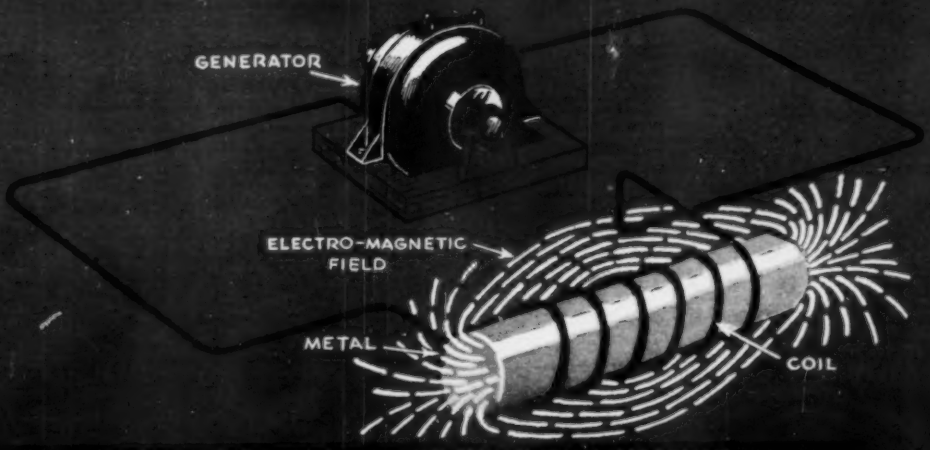
On the civilian front, too, induction heating works like a Turk. It's far more useful than most of us realize. Nearly every time we shave with a sharp razor blade, get fine music from a long-lasting phonograph needle, plug in our radio, or do an exceptional job in our home workshop with good tools, we can thank an induction furnace. For, more than likely, it was used in melting, forging, brazing, case-hardening, welding, or soldering those items so perfectly.

This metallurgical master worker dates its success story from the last war. Edwin F. Northrup devised it as a means of speeding production. Though too late for use then, its debut attracted wide attention among American industrialists. Before 1942 our industry had installed induction heating equipment using 175,000,000 watts, and in that year war plants accounted for more installations than in any previous three-year period.

Northrup's basic principle still holds good, although furnaces themselves have undergone many refinements to attain production wizardry. It's the same principle that is used in an ordinary transformer. In fact, if you strip off the manifold mechanical gadgets from an induction furnace, you have little more than an insulated box built around a transformer whose core has been removed to make room for whatever metal you want to heat. Heating occurs almost instantaneously when you send an electric current through the transformer coil surrounding the metal to be treated. The induced voltage, encountering resistance in the metal, produces a power loss which appears as heat. By varying the frequency and strength of the current and the size of the coils, you can control the depth of heat penetration, the area affected by the heat, and the temperature. Just push a few buttons and you can give the metal any kind of treatment desired.

Engineers have compared induction heat with the radiant heat thrown off by the sun. When the sun's rays pass through space, there is slight loss of energy, and thus negligible heat is produced. But when they strike a dark body, its surface is heated. In like manner, high-frequency magnetic waves from the coil pass through all insulating ma-

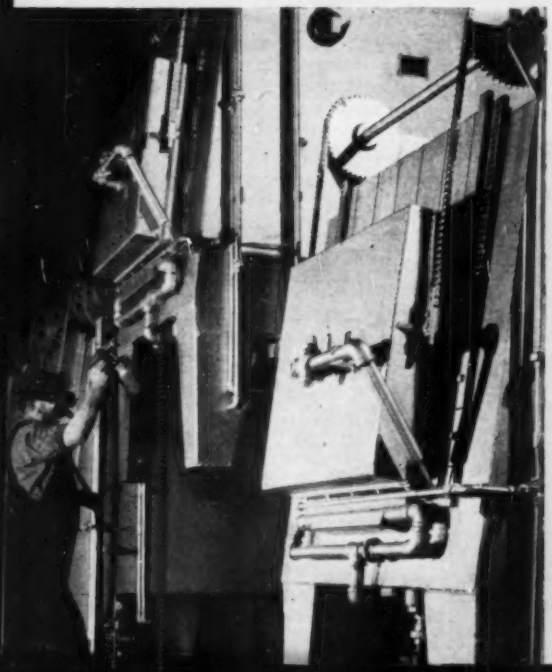
HOT FOR THE AXIS

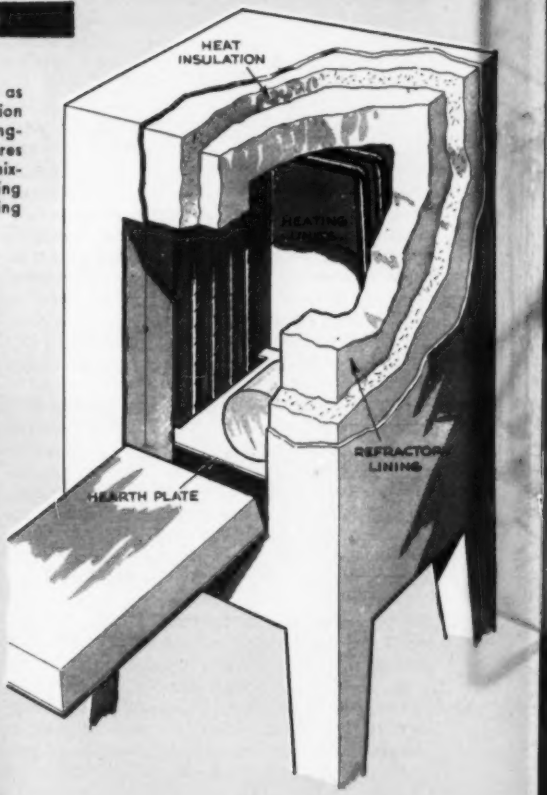


THIS IS THE PRINCIPLE OF INDUCTION HEATING

HOW THE PRINCIPLE IS APPLIED

Hundreds of electric heat-treating furnaces, such as those shown below, are being used to harden precision parts required in planes and tanks. Made by Westinghouse, these furnaces do their work at temperatures ranging between 1,500 and 2,000 degrees F. A gas mixture known as Endogas is introduced into the heating chamber to protect the work from scaling or softening





terials without dissipating their energies, yet create heat when they strike a metal body. Nonconducting materials which enter the magnetic field—intervening air, for example, or parts of the human body—are not affected. This explains why a man can place his hand within an induction furnace without suffering the slightest injury, though a piece of metal put there will soon be white-hot.

Induction furnaces now being used in the manufacture of so many of our weapons of war require an alternating current of high frequency. In that type of current, the magnetic lines of force change direction rapidly, threading the metal within the coil and setting up the current there that develops the heat. Direct current will not do the job.

In many installations, tubing is used instead of wire in the inductor coil. This is possible because of the "skin effect" characteristic of the alternating current, a tendency of the current to concentrate on the surface of the conductor, especially at high frequencies. Crowding of the current on the surface enables the induction furnace to attain remarkable results in hardening metals and gives it a "stirring effect" extremely valuable in melting operations. Because of it, shallow-layer objects, such as shell casings and crankshafts, can be heated so quickly that underlying portions are not affected, and alloys of homogeneous nature can be formed through thorough mixing.

Continuous furnaces—that is, relays of furnaces—have now been designed to meet needs in specialized industries. They are equipped with conveyors or mechanical carrying devices and have accurate time and temperature controls. Furnace ratings, depending on the particular operation, run anywhere from a few kilowatts to as many as 1,200 kilowatts. In some cases, engineers have designed ingenious mechanisms to handle materials entirely automatically.

Perfecting of protective atmospheres for use in the heating process is another step forward. By means of gases applied so as to surround metal parts, the operators are now able to prevent oxidation and decarbonization. The open-fire method of heat-treating never has been without possibility of distortion and chemical alteration of the metal, requiring lengthy and expensive sand-blasting, pickling, machining, and grinding operations after the treatment. Faster, better-controlled heating provided by the induction furnace saves time and money, since there are no blemishes or marring results. Equipment now available maintains a protective atmosphere in the furnace.

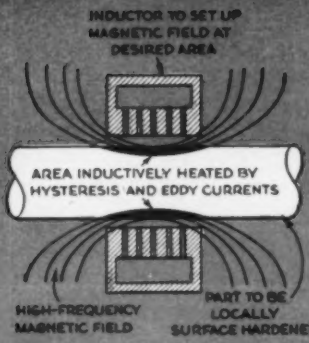
Induction heat often figures in the headlines these days from war-production lines. One of the most spectacular advances in gunsmithing—the centrifugal casting of gun barrels—is a direct outgrowth of research in this field. Traditionally, gun barrels have been fashioned laboriously from ingots, forged, heat-treated by conventional methods, and then machined into shape. But ordnance experts hit upon the idea of simplifying the process with the aid of electric furnaces. Widely used today is a process in which ingredients which make up steel for the barrel are melted in an induction furnace, where alloying is rapid and melting losses low. Metal is carried in the furnace itself, which doubles as a giant ladle, and is poured into a horizontally rotating mold. The mold is turned until the casting solidifies. Now, when you remove the barrel from the casting machine, you find it easy to finish.

Centrifugal forces have done the lion's share of the work. As the rotating occurs, the barrel has taken shape, not as a solid ingot requiring expensive hollow-forging or machining operations, but as one already having a hole through the center. Moreover, any slag particles or impurities present in the mold, being lighter than the steel through which they are dispersed, float to the bore. You can quickly get rid of them in the machining process.

Induction heating is particularly well suited for forming, brazing, and hardening operations in making projectiles. Its chief advantages are speed and uniformity of heating, ease in controlling heat to specific patterns, the metal's freedom from surface scale after treatment, and greatly improved working conditions for operators. Another consideration recognized by farsighted industrialists is the fact that induction-heating equipment can be turned to peacetime use without investment loss. Indeed, post-war plans have inspired many industrialists to put in electric furnaces. For instance, while a frequency of 1,000 cycles is sufficient for heating many weapons, most manufacturers have installed 2,000-cycle furnaces because they can be more readily converted to automotive work after the war.

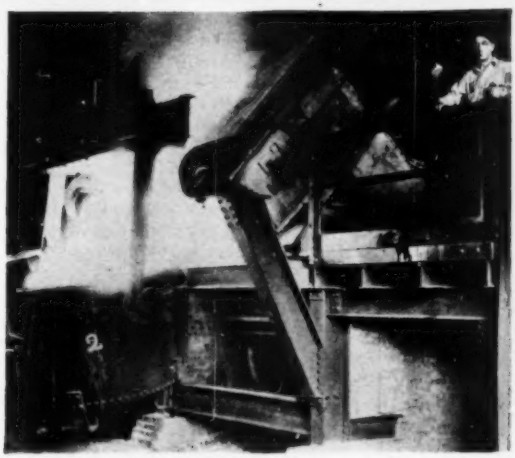
Great is the variety of tasks that induction furnaces perform. They are used to expand metal parts, or to shrink those parts for fitting; they treat the nichrome (nickel chromium) wire used in spark plugs, tune the tungsten contact points found in virtually all gas motors. Alnico magnet steel used in radio and meter parts is almost exclusively a product of induction heating. In radio and radio-control equipment, induction heating is used to drive off occluded gases from metal parts in sealing vacuum tubes. It's in nearly all Navy yards, Army ordnance plants, arsenals, and war plants where special alloys and castings are made. Every day they find new uses for this versatile furnace to put more heat on the Axis.

An induction machine heats the corner of a tool shank on which a tungsten-carbide tip is to be brazed


INDUCTOR TO SET UP MAGNETIC FIELD AT DESIRED AREA
AREA INDUCTIVELY HEATED BY HYSTERESIS AND EDDY CURRENTS
HIGH-FREQUENCY MAGNETIC FIELD
PART TO BE LOCALLY SURFACE HARDENED

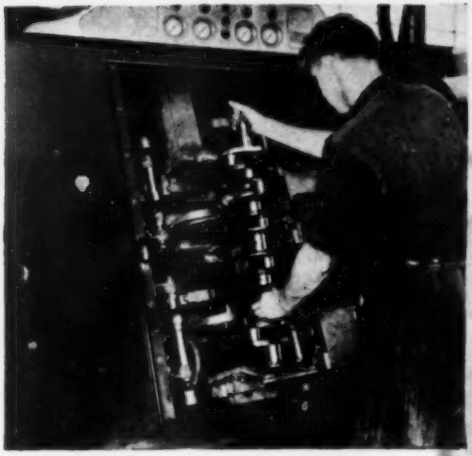
Induction heating can harden the teeth of a sprocket—and leave remainder unaffected

INDUCTION PUTS THE HEAT JUST WHERE IT IS NEEDED



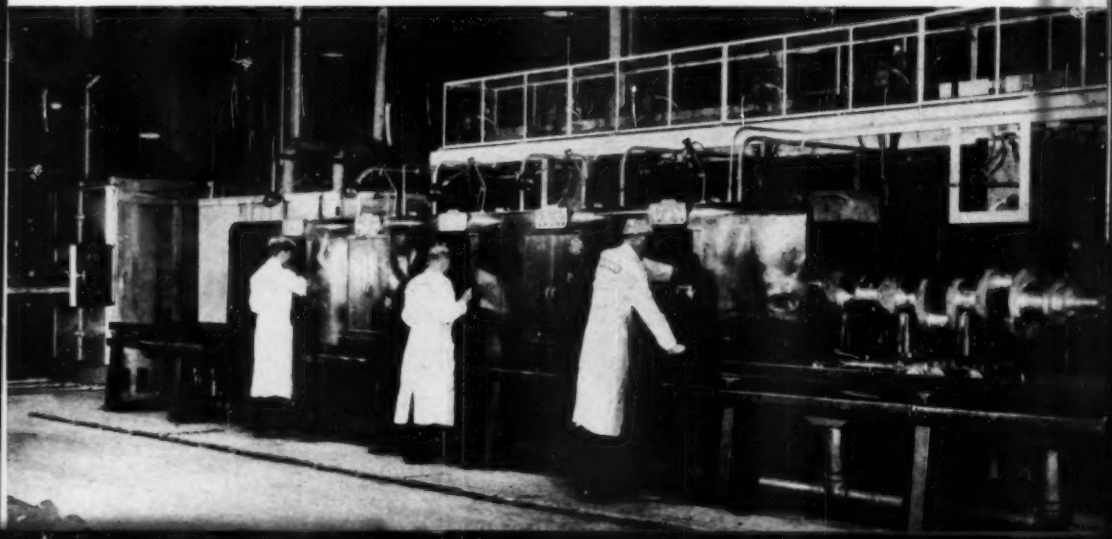
Ajax Electrothermic Corp.

In compounding alloys, an electric furnace's electromagnetic forces automatically "stir" the ingredients, and thus aid the mixing. Melting is speeded up by concentrating the current into small charges



Here is another instance of how induction heating can restrict its effect to a given area. The crankshaft above is about to get a heat treatment that will harden only its bearing surfaces

An extra-long crankshaft is shown below being hardened in a machine that carries an inductor block for each bearing. By varying the size of the coils, as well as the power and frequency of the current (which, for all induction work, must be alternating), both the depth and degree of hardening can be accurately controlled



What You Should Know About

Propellers for Our Fighting

The modern aircraft propeller is an amazingly ingenious mechanism designed to get maximum efficiency of engine and plane.

By JAMES L. H. PECK

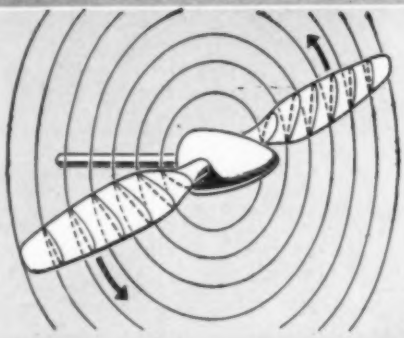
Drawings by STEWART ROUSE

AFTER a recent battle, American forces captured a German soldier who kept pointing upward and babbling about "big whirling swords." Some time later, doctors discovered the cause of his hallucinations. Lightning and Warhawk fighters had run interference for the Yank advance by carrying out one of their blistering strafing attacks at tree-top altitude. The Nazi had somehow escaped from his flaming tank and survived the assault; but, in his fear, he had psychologically identified the sunlit, spinning propeller blades of the low-sweeping planes as whirling swords.

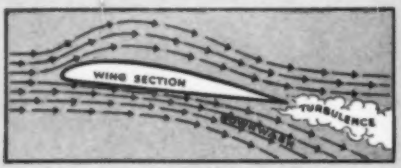
Indeed, in a more practical manner, the whirling prop blades of our warplanes do symbolize their deadliness. The propellers that pull our fighters and bombers—and those of our allies—through the skies over half a dozen war theaters are more than a little responsible for the superb performance that is affording American-made craft the air superiority they now enjoy. The prop is as much a part of the plane's power plant as is the engine. It translates the engine's power output into the "thrust" necessary for sustained flight.

If we consider the propeller as a screw working its way through the air and pulling the plane along—or pushing it along, if it is mounted aft of the engine, as in the case of

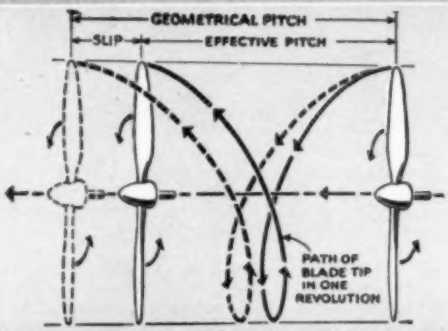
A PROPELLER BLADE IS A SPINNING WING. HERE'S WHAT

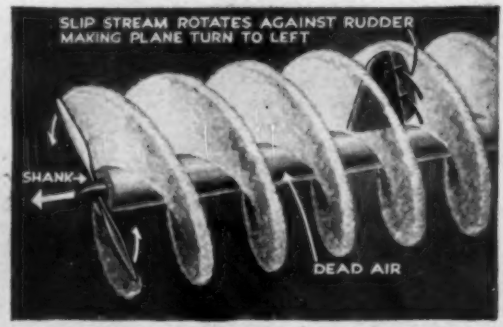


Essentially a set of spinning airfoils, a propeller's blades are shaped like a plane's wings. However, since the tips travel at a higher speed than parts nearer the hub, the blade angle must be varied progressively, decreasing from the shank toward the tip



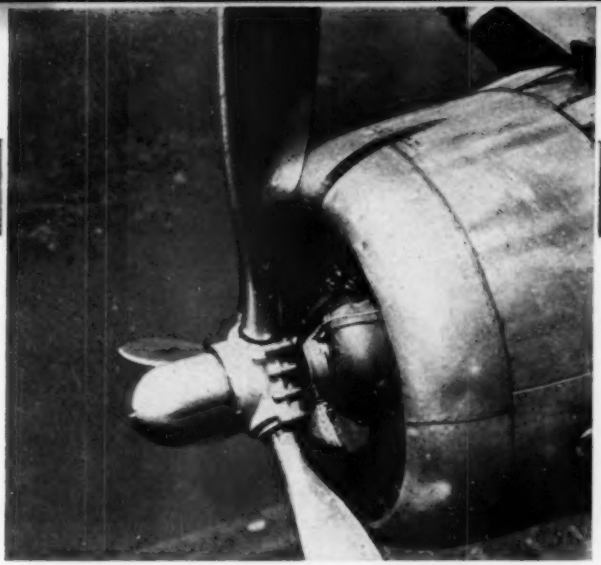
A wing gets its lift from the partial vacuum created above it, and from pressure below. Corresponding forces give a propeller its pull





Slip stream of a propeller is the equivalent of the downwash from a wing. It takes the form of a corkscrew spiral of air which upsets steering equilibrium

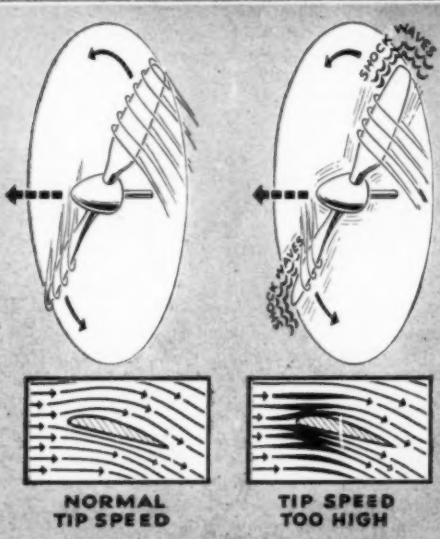
Planes



Feathering keeps a dead engine from being damaged by "windmilling"

our Bell Airacuda and some of the new pusher-type fighters—just as a steel screw bores its way through a piece of wood, the principle of propulsion is reduced to its simplest terms. But, unlike the screw, which advances by pushing the rear face of its thread against the fibers of the wood, the prop advances by creating just ahead of its whirling blades an area of suction into which they are drawn. The propeller blades are shaped exactly like the wing section of a plane and act on the same principle. The prop is, to all intents and purposes, a set of spinning airfoils.

HAPPENS WHEN IT REVOLVES



The faster the propeller turns, the more thrust it produces, until its tip speed approaches the velocity of sound (1,100 feet per second), where there is a sudden and overwhelming increase in drag. Pressure waves set up at the leading edge cannot get out of the way of the moving blade, and must be dragged along. This phenomenon puts limits on length of blades and on propeller speed

Just as the airplane wing must move forward fast to maintain its lifting properties, the propeller must rotate swiftly in order to provide thrust. The faster it turns, the more thrust results—up to a certain point. And, just as the wing is tilted upward slightly in order to deflect the air downward (this setting is called "angle of attack"), the prop's blades are twisted so as to deflect the air rearward. This twist, or "blade angle," enables the blades to meet the air at an angle that is most favorable for thrusting efficiency.

In rotating, the tips of the propeller must travel around their greater radius within the same time that the prop hub completes a revolution. The tips, therefore, travel may times faster than the center of the prop. For this reason, the blades are not straight like a wing but twisted so as to permit the blades to meet the air at the optimum angle along the entire length of the propeller. The twist is most noticeable in the inner half of the blade. Within a foot or so of the hub, the blade merges from its flat shape into a round, thick section that provides no thrust whatsoever.

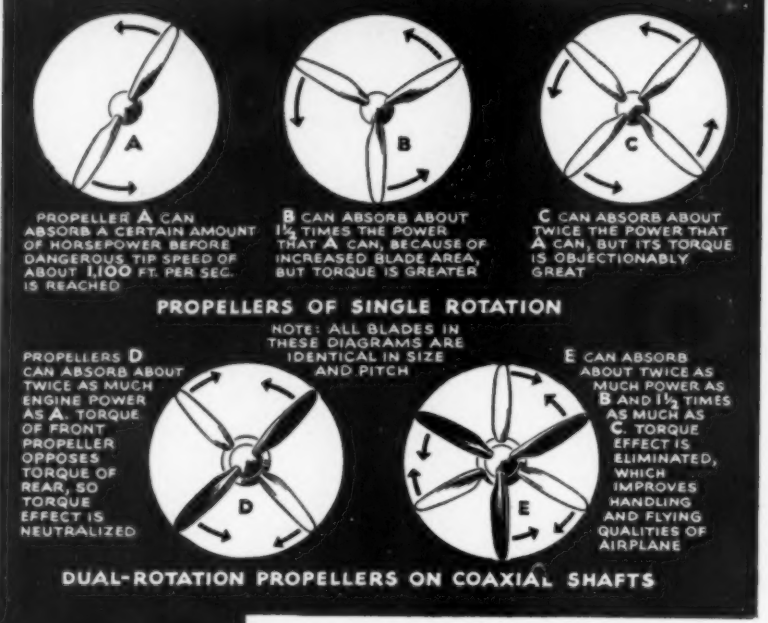
The very same laws of physics which permit a wing to lift or a propeller to thrust have decreed that we must pay a price for these aeronautical services. The steepest of these prices is drag. It is with drag that the propeller must struggle constantly as it pulls or pushes the plane through the air. Drag acts on the prop in the same way as on the wing, only more so because of the high speeds at which the prop rotates. Drag may be diminished by giving the wing section or prop blade a more streamlined shape. The new laminar-flow wing section—used

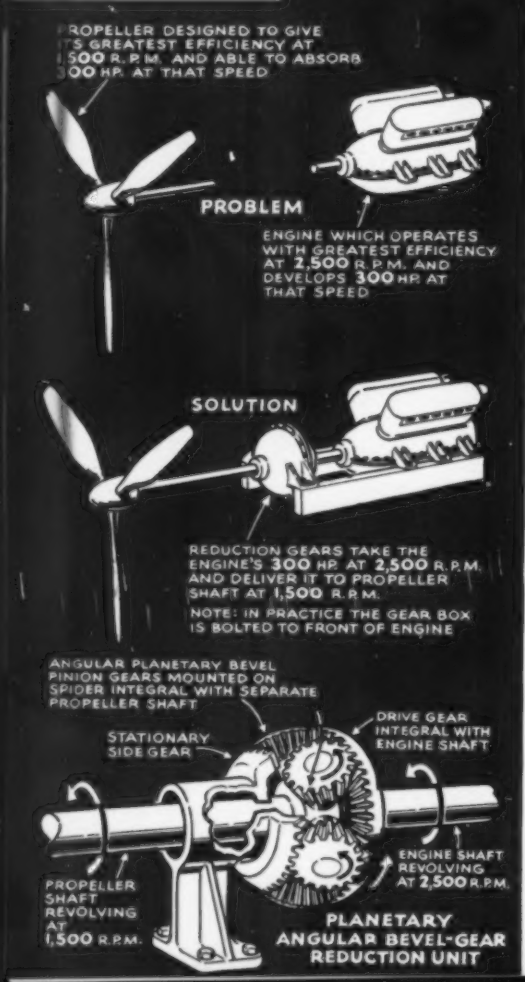
GIVING PROP MORE POWER

With the use of more powerful engines, propellers must be adapted to absorb that power. The drawings at right show how engineers solve the problem, increasing blade surface while holding down length

MATING PROP TO ENGINE

Another difficulty arises from the fact that props and engines have different speeds for maximum efficiency. The answer to this is a reduction gear that enables the prop to turn at lower speed than engine


A
B
C
PROPELLER A CAN ABSORB A CERTAIN AMOUNT OF HORSEPOWER BEFORE DANGEROUS TIP SPEED OF ABOUT 1,100 FT. PER SEC. IS REACHED
B CAN ABSORB ABOUT 1½ TIMES THE POWER THAT A CAN, BECAUSE OF INCREASED BLADE AREA, BUT TORQUE IS GREATER
C CAN ABSORB ABOUT TWICE THE POWER THAT A CAN, BUT ITS TORQUE IS OBJECTIONABLY GREAT
PROPELLERS OF SINGLE ROTATION
NOTE: ALL BLADES IN THESE DIAGRAMS ARE IDENTICAL IN SIZE AND PITCH
PROPELLERS D CAN ABSORB ABOUT TWICE AS MUCH ENGINE POWER AS A. TORQUE OF FRONT PROPELLER OPPOSES TORQUE OF REAR, SO TORQUE EFFECT IS NEUTRALIZED
D
E
E CAN ABSORB ABOUT TWICE AS MUCH POWER AS B AND 1½ TIMES AS MUCH AS C. TORQUE EFFECT IS ELIMINATED, WHICH IMPROVES HANDLING AND FLYING QUALITIES OF AIRPLANE
DUAL-ROTATION PROPELLERS ON COAXIAL SHAFTS

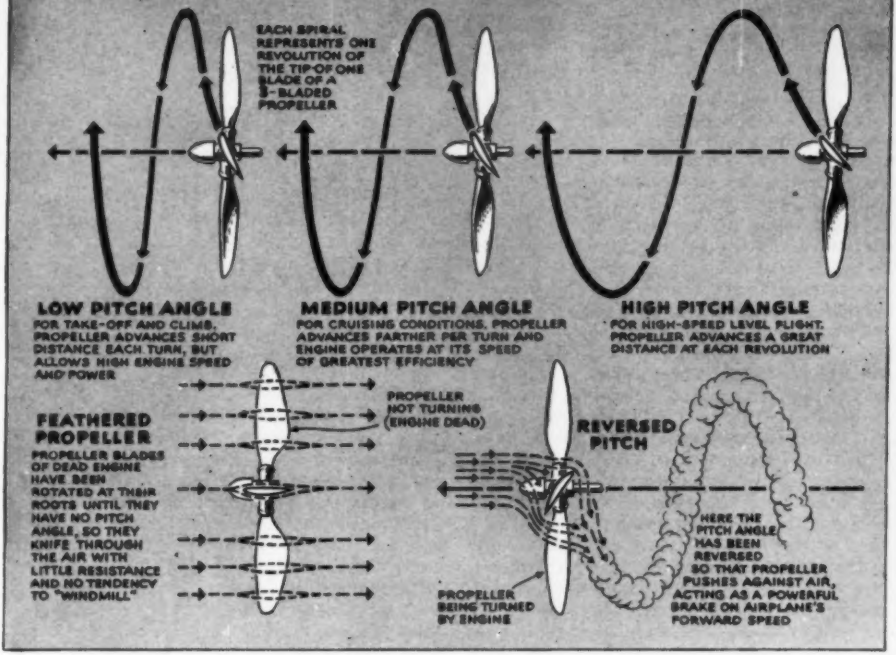

PROPELLER DESIGNED TO GIVE ITS GREATEST EFFICIENCY AT 1,500 R.P.M. AND ABLE TO ABSORB 300 H.P. AT THAT SPEED
PROBLEM
ENGINE WHICH OPERATES WITH GREATEST EFFICIENCY AT 2,500 R.P.M. AND DEVELOPS 300 H.P. AT THAT SPEED
SOLUTION
REDUCTION GEARS TAKE THE ENGINE'S 300 H.P. AT 2,500 R.P.M. AND DELIVER IT TO PROPELLER SHAFT AT 1,500 R.P.M.
NOTE: IN PRACTICE THE GEAR BOX IS BOLTED TO FRONT OF ENGINE
ANGULAR PLANETARY BEVEL PINION GEARS MOUNTED ON SPIDER INTEGRAL WITH SEPARATE PROPELLER SHAFT
STATIONARY SIDE GEAR
DRIVE GEAR INTEGRAL WITH ENGINE SHAFT
ENGINE SHAFT REVOLVING AT 2,500 R.P.M.
PROPELLER SHAFT REVOLVING AT 1,500 R.P.M.
PLANETARY ANGULAR BEVEL-GEAR REDUCTION UNIT

on the superb North American Mustang fighter-bomber and other American craft—has reduced drag almost 67 percent, and this same type of airfoil section is used by some of our propeller manufacturers.

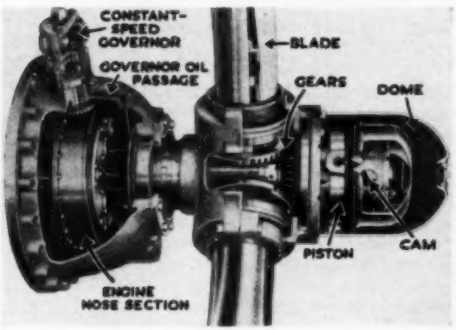
Greater efficiency may also be achieved by increasing the area of the blade to provide more thrust, but it is here that the engineers encounter trouble. The diameter of the propellers is limited by three considerations: on single-engined craft, the prop must be short enough to allow clearance when the ship is on the ground on level keel. On multiengined planes, ground clearance is not such an important factor because these ships are larger and sit higher, but using bigger props means moving the engines farther apart (and the outboard engines farther out on the wing). When these difficulties are overcome, there remains still another: the larger the propeller's diameter, the higher the tip speed. When the tips of the prop reach the speed of sound—1,100 feet per second—they become literally barnacled with a peculiar and exaggerated drag condition called a "shock wave." There are limitations on the width of the blades, too. As the blade is widened, it must be made heavier for structural reasons, and this results in greater drag and weight. Compromise is necessary for other reasons which have to do with more involved aerodynamic laws, and the product is the neatly tapered, knifelike propeller blade we see on today's warplanes and airliners.

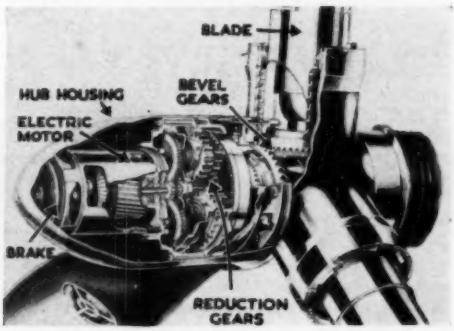
Notwithstanding these difficulties, the propeller is just about the most efficient part of the airplane. How it got that way is somewhat of a story. Some of the earlier props

VARIABLE-PITCH PROPELLER HAS WIDE RANGE OF EFFICIENCY


EACH SPIRAL REPRESENTS ONE REVOLUTION OF THE TIP OF ONE BLADE OF A 3-BLADED PROPELLER
LOW PITCH ANGLE
FOR TAKE-OFF AND CLIMB, PROPELLER ADVANCES SHORT DISTANCE EACH TURN, BUT ALLOWS HIGH ENGINE SPEED AND POWER
MEDIUM PITCH ANGLE
FOR CRUISING CONDITIONS, PROPELLER ADVANCES FARTHER PER TURN AND ENGINE OPERATES AT ITS SPEED OF GREATEST EFFICIENCY
HIGH PITCH ANGLE
FOR HIGH-SPEED LEVEL FLIGHT, PROPELLER ADVANCES A GREAT DISTANCE AT EACH REVOLUTION
FEATHERED PROPELLER
PROPELLER BLADES OF DEAD ENGINE HAVE BEEN ROTATED AT THEIR ROOTS UNTIL THEY HAVE NO PITCH ANGLE, SO THEY KNIFE THROUGH THE AIR WITH LITTLE RESISTANCE AND NO TENDENCY TO "WINDMILL"
PROPELLER NOT TURNING (ENGINE DEAD)
REVERSED PITCH
HERE THE PITCH ANGLE HAS BEEN REVERSED SO THAT PROPELLER PUSHES AGAINST AIR, ACTING AS A POWERFUL BRAKE ON AIRPLANE'S FORWARD SPEED
PROPELLER BEING TURNED BY ENGINE

HOW PITCH OF PROPELLER BLADES IS VARIED IN FLIGHT

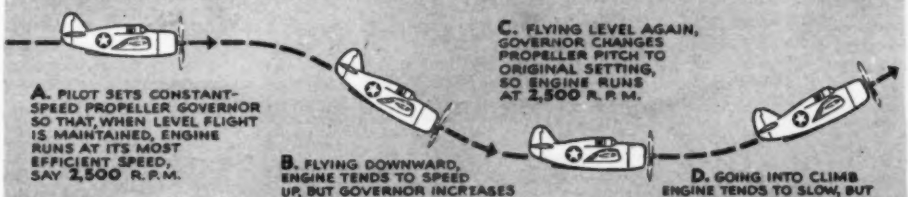




HYDRAULIC. In this Hamilton Standard Hydromatic hub mechanism, a piston moved by hydraulic pressure operates gearing and cams to increase or decrease the pitch of the blades. A governor maintains pressure balance for constant-speed operation

ELECTRIC. The Curtiss Electric uses a motor to turn the blades through a set of planetary and bevel gears. A brake on the motor locks the blades in the desired position when current is off. Constant-speed operation is given by governor, switches

CONSTANT-SPEED PROPELLER KEEPS ENGINE AT MOST EFFICIENT SPEED



A. PILOT SETS CONSTANT-SPEED PROPELLER GOVERNOR SO THAT, WHEN LEVEL FLIGHT IS MAINTAINED, ENGINE RUNS AT ITS MOST EFFICIENT SPEED, SAY 2,500 R.P.M.

B. FLYING DOWNWARD, ENGINE TENDS TO SPEED UP, BUT GOVERNOR INCREASES PITCH OF BLADES SO THE PROPELLER ACTS AS A BRAKE ON THE ENGINE, KEEPING IT AT 2,500 R.P.M. THOUGH THE PLANE IS FLYING FASTER

C. FLYING LEVEL AGAIN, GOVERNOR CHANGES PROPELLER PITCH TO ORIGINAL SETTING, SO ENGINE RUNS AT 2,500 R.P.M.

D. GOING INTO CLIMB ENGINE TENDS TO SLOW, BUT GOVERNOR FLATTENS PITCH OF PROPELLER, MAKING IT EASIER TO TURN, SO ENGINE KEEPS ON RUNNING AT 2,500 R.P.M.

were nothing more than twisted airfoils, the blades being built up of wooden ribs and covered with cloth. Then they were hewn out of a solid piece of timber. The first really serviceable propellers were made of laminated wood; these proved reliable and aerodynamically efficient throughout the crucial years of aviation, and some of this type are still used for small civil planes and military trainers.

Early experiments with steel propellers were conducted in 1917, prompted by maintenance difficulties in World War I. During the next two years, several hollow steel props were tested by the Army Air Corps, and one solid steel model performed satisfactorily. In 1921, earnest development of the aluminum-alloy blade was undertaken, and the ease of making blades from solid stock, as compared with the expense of fabricating hollow steel blades by the then available methods, made aluminum more desirable. These dural blades and hubs gained wide popularity, and the steel-prop development lagged.

The improvement in performance and durability brought metal propellers into almost universal use during the late 20's; the most famous of these were the Hamilton Standard and Curtiss Reed, both made of dural. These props, of course, had a fixed blade angle, or pitch. As long as aircraft engines remained in the 500-horsepower bracket and 160 miles per hour was considered a lot of speed, the fixed-pitch propeller was adequate. As engines became more powerful and the demands for performance increased, power-plant limitations were relieved by the introduction of the adjustable-pitch prop, whose blades could be set to low or high pitch—or a happy medium—and clamped securely in the hub. In low pitch, the plane had fine take-off and climbing characteristics but was short on speed: in high pitch, with the blades turned to meet the air at a greater angle, the plane developed maximum speed but its take-off and climbing ability was not what it might have been. A compromise setting, however, gave the craft good all-around performance.

NEUTRALIZING TORQUE. The simplest way to counteract this turning effect on the plane is, of course, to have two engines with props rotating in opposite directions, as in the P-38

As the pioneers had pointed out many years before, what the flyer really needed was a propeller whose pitch settings could be changed during flight. In 1933, the Collier Trophy was awarded to Hamilton Standard for the development of a successful controllable-pitch propeller whose blades could be set at high or low hydraulically through a control in the cockpit that actuated the hub mechanism. During the same year, Curtiss perfected an electrically controlled propeller. By taking off with the prop blades in low pitch, flyers got their ships off the ground in 35 percent of the distance formerly required and increased their rate of climb approximately 30 percent. When they reached the desired altitude, the shift was made to high pitch, with the result that top speed was increased almost 15 percent. For higher flights, an additional 20-percent increase in the plane's service ceiling was obtained. The ingenuity of Hamilton Standard and Curtiss-Wright engineers greatly influenced airplane and engine design by making possible the use of larger and faster military craft and transports. The Lycoming-Smith electric controllable-speed prop became popular for lower-powered civil airplanes.

But with the advent of 1,000-horsepower engines, this business of changing blade pitch required further refinement. The engine and prop have to be carefully mated; for maximum performance, each has to

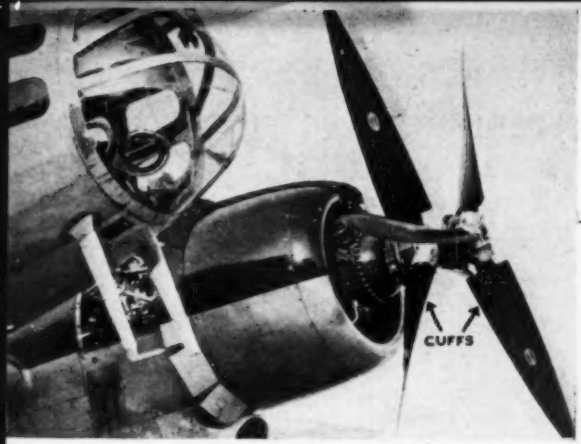
DUAL-ROTATION PROPS PERMIT MORE POWER FOR FIGHTERS

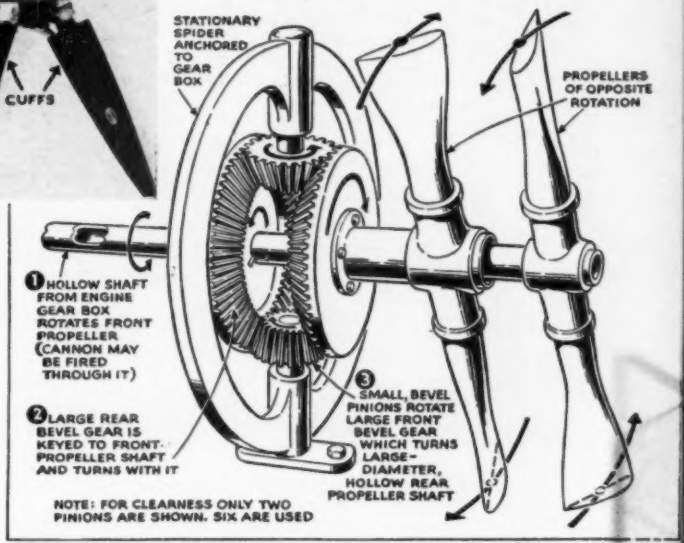
Suppose you were a designer and had the task of adapting an existing fighter type to use an engine of greater power. It would be easy to increase the size of the plane, but a single propeller large enough to absorb the extra power would require a higher landing gear, and its tip speed would be dangerously high. Also, torque would be troublesome. A dual-rotation prop solves these problems

PROPELLER ABSORBS POWER WITHOUT EXCESSIVE TIP SPEED, BUT TORQUE IS TROUBLESOME
1,000 HP
GROUND CLEARANCE
PROPELLER ABSORBS POWER, BUT WITH DANGEROUS TIP SPEED AND TORQUE
2,000 HP
HIGH, HEAVY LANDING GEAR TAKES TOO MUCH SPACE WHEN RETRACTED
TWO PROPELLERS, ONE LIKE THAT OF AIRPLANE A AND ANOTHER OF OPPOSITE ROTATION, ABSORB POWER WITH SAFE TIP SPEED AND ELIMINATE TORQUE
2,000 HP
SMALL, RETRACTS WELL
AIRPLANE A, A NORMAL, SUCCESSFUL FIGHTER DESIGN
AIRPLANE B, SIMILAR TO A, BUT LARGER, USING 2,000 HP ENGINE AND HUGE PROPELLER OF SINGLE ROTATION
AIRPLANE B, EQUIPPED WITH DUAL-ROTATION PROPELLERS ON COAXIAL SHAFTS

DUAL ROTATION

Ultimate in props today is the dual-rotation job of four or six blades, consisting of two units on coaxial shafts which turn in opposite directions. At the left is a Hamilton Standard Hydromatic installation on a Douglas B-23 medium bomber. The small knob behind the near blade tip is the constant-speed governor. Simplified drawing shows how prop works

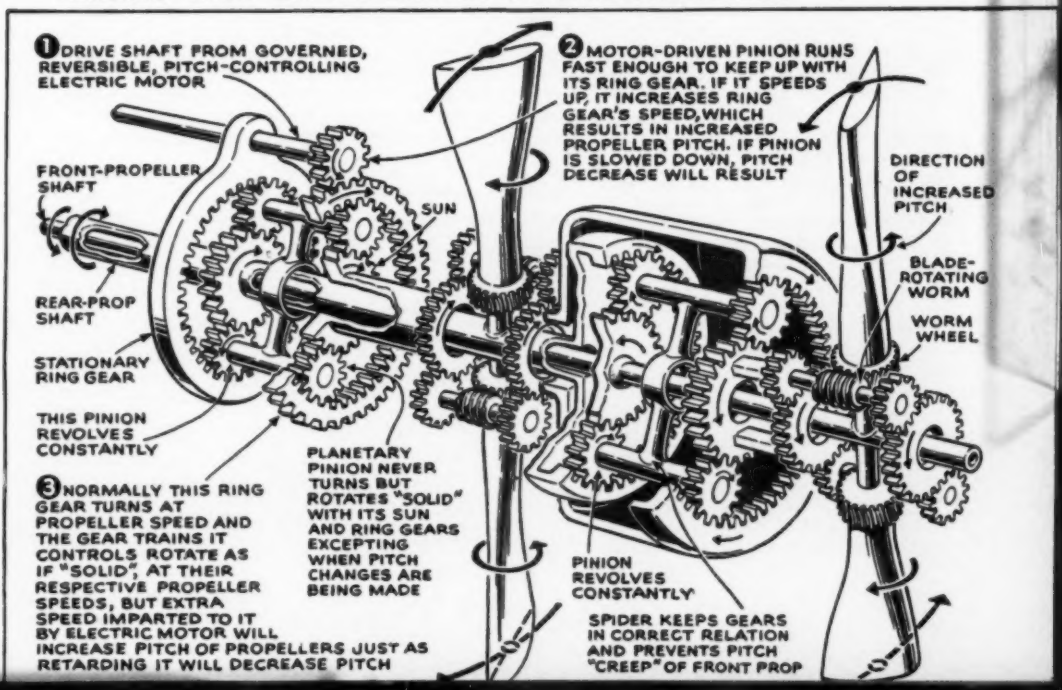



STATIONARY SPIDER ANCHORED TO GEAR BOX
PROPELLERS OF OPPOSITE ROTATION
1 HOLLOW SHAFT FROM ENGINE GEAR BOX ROTATES FRONT PROPELLER (CANNON MAY BE FIRED THROUGH IT)
2 LARGE REAR BEVEL GEAR IS KEYED TO FRONT PROPELLER SHAFT AND TURNS WITH IT
3 SMALL BEVEL PINIONS ROTATE LARGE FRONT BEVEL GEAR WHICH TURNS LARGE-DIAMETER, HOLLOW REAR PROPELLER SHAFT
NOTE: FOR CLEARNESS ONLY TWO PINIONS ARE SHOWN. SIX ARE USED

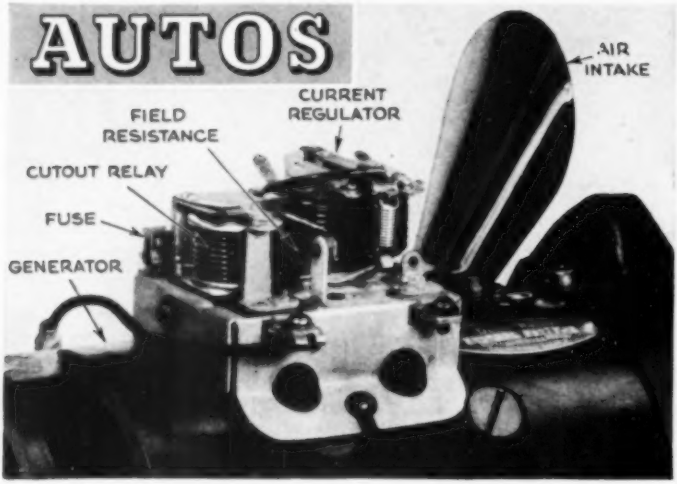
make concessions to the other, and for every combination of engine and propeller there is an optimum speed for the two. The engine's top power output is gained at a constant r.p.m., or crankshaft speed. This is generally higher than the propeller's optimum speed, and reduction gears are set into the engine nose section to slow down the prop to three quarters or half the engine speed.

In its job of translating the engine's horsepower into useful thrust, the prop also acts as a brake on the engine. But this braking effect must be carefully controlled or the engine will not function at its best. The two-position propeller is not sufficiently flexible in its operation to absorb the output of today's high-powered, highly super- *(Continued on page 212)*

VARYING PITCH ON AN ELECTRIC DUAL-ROTATION PROP


1 DRIVE SHAFT FROM GOVERNED, REVERSIBLE, PITCH-CONTROLLING ELECTRIC MOTOR
2 MOTOR-DRIVEN PINION RUNS FAST ENOUGH TO KEEP UP WITH ITS RING GEAR. IF IT SPEEDS UP, IT INCREASES RING GEAR'S SPEED, WHICH RESULTS IN INCREASED PROPELLER PITCH. IF PINION IS SLOWED DOWN, PITCH DECREASE WILL RESULT
FRONT-PROPELLER SHAFT
SUN
DIRECTION OF INCREASED PITCH
BLADE-ROTATING WORM
WORM WHEEL
REAR-PROP SHAFT
STATIONARY RING GEAR
THIS PINION REVOLVES CONSTANTLY
PLANETARY PINION NEVER TURNS BUT ROTATES "SOLID" WITH ITS SUN AND RING GEARS EXCEPTING WHEN PITCH CHANGES ARE BEING MADE
3 NORMALLY THIS RING GEAR TURNS AT PROPELLER SPEED AND THE GEAR TRAINS IT CONTROLS ROTATE AS IF "SOLID", AT THEIR RESPECTIVE PROPELLER SPEEDS, BUT EXTRA SPEED IMPARTED TO IT BY ELECTRIC MOTOR WILL INCREASE PITCH OF PROPELLERS JUST AS RETARDING IT WILL DECREASE PITCH
PINION REVOLVES CONSTANTLY
SPIDER KEEPS GEARS IN CORRECT RELATION AND PREVENTS PITCH "CREEP" OF FRONT PROP

Keying Your Generator



Sensitive relays for governing the output of the generator are the electrical nerve centers of a car. At the left is pictured a two-unit type. The air scoop is part of the air-cooling system of the generator.

By RALPH ROGERS

GASOLINE rationing has in many cases taxed the capacities of automobile electrical systems to the utmost. Modern generator regulators are ingeniously designed to maintain, so far as possible, a full battery charge under all circumstances of car use. But when under rationing a car is not used sufficiently, even the flexibility of these devices may not be adequate to keep a battery from becoming discharged. Hence in some instances it is desirable to change the regulator adjustments somewhat to compensate for rationed driving.

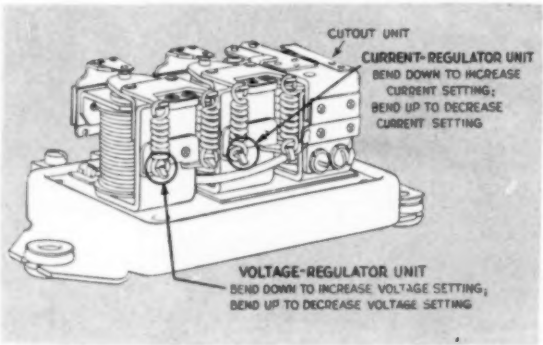
About a decade ago, before defrosters, radios, heaters, and other electrical accessories were in general use, the low-output, third-brush generator provided ample current to meet the ignition and lighting requirements of the average automobile. With this type of generator, it was a simple matter to adjust electrical output. By moving the third brush in the direction of armature rotation, output was increased; by moving it against rotation, output was decreased.

To carry the additional load imposed both by numerous accessories and by more powerful lighting and ignition systems, the generator output in more recent cars has been greatly increased. This has necessitated the use of additional means to control the generator and thereby protect the battery and lighting system.

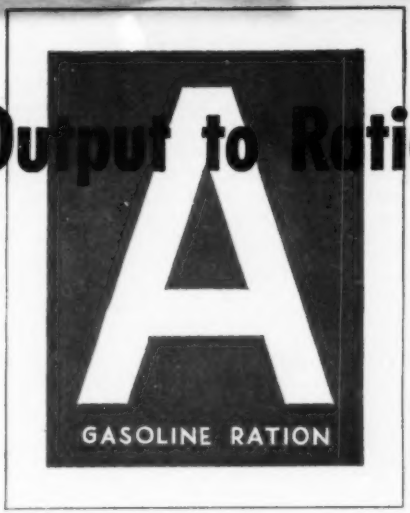
Today, most passenger-car generators are controlled by a three-unit regulator which consists of a cutout relay, a current-limiting device, and a voltage-limiting device. However, a few cars are equipped with a two-unit regulator consisting of a cutout relay and a voltage-limiting device; control of the current is provided by a fixed third brush on the generator which flattens out the curve of current output. The operation of the two units in this kind of regulator is the same as that of the corresponding parts in the three-unit type.

The function of the cutout relay, of

The way to make current and voltage adjustments on a common regulator is shown below. Bend one spring hanger at a time


CUTOUT UNIT
CURRENT-REGULATOR UNIT
BEND DOWN TO INCREASE CURRENT SETTING; BEND UP TO DECREASE CURRENT SETTING
VOLTAGE-REGULATOR UNIT
BEND DOWN TO INCREASE VOLTAGE SETTING; BEND UP TO DECREASE VOLTAGE SETTING

Output to Rationed Driving



course, is to disconnect the generator from the battery when the generator output is insufficient to charge the battery. The other two regulators provide control over the generator output under varying conditions of generator speed, electrical load, and battery charge. Each of the three units is, in effect, a magnetic switch. The cutout closes and opens the main charging circuit as motor speed increases and decreases. (Without the cutout, battery current would drain back through the generator when the motor is idling.)

The current regulator opens and closes the field circuit, rapidly inserting and removing resistance, when the generator has reached its maximum rated output. The voltage regulator also inserts and removes resistance in the field circuit when the voltage of the system reaches its safe maximum, thus preventing battery overcharge and excessive voltage.

Before you change any adjustments on the regulator, first make an inspection of the electrical system. Check the condition of the battery and see that the generator drive belt has the proper tension. Examine the generator for worn or sticking brushes, dirty commutator, defective field coils or armature, a grounded brush-holder, or weak brush springs.

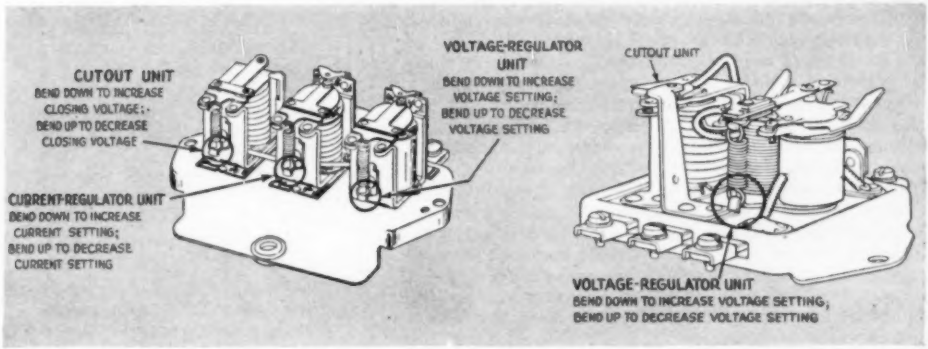
As a rule, the settings of a generator regulator will seldom change much during operation, although some variation may be caused by point wear, vibration, and temperature changes. The settings may sometimes need readjustment to compensate for some unusual condition of operation. For example, in semitropical climates, the voltage-regulator setting may have to be lowered somewhat, since a warm battery has a lesser resistance to current than a cold one.

With batteries handicapped by rationed driving, one common servicing job these days is to check on the efficient operation of regulators. The three drawings on this and the facing page show how to adjust common types of regulators. Because a regulator is a complicated and sensitive device, it isn't wise to change the settings yourself unless the need is clear-cut and no automotive electrician is available. Do not increase the current regulator setting to more than the rated generator output (which is obtainable from the manufacturer's data sheet if it is not stamped on the generator), because serious damage may result. Remember also that a slight bending of the spring clips will result in a substantial difference in regulator performance. An accurate ammeter and voltmeter are essential to precision adjustments; the dashboard meter will not do.

In servicing a regulator, there are also some specific rules to bear in mind:

1. Each type of regulator has been de-

Another typical three-unit regulator is shown at the left. The regulator at the right, which has no current-control unit, is used with a third-brush generator having a relatively constant current output


CUTOUT UNIT
BEND DOWN TO INCREASE CLOSING VOLTAGE; BEND UP TO DECREASE CLOSING VOLTAGE
VOLTAGE-REGULATOR UNIT
BEND DOWN TO INCREASE VOLTAGE SETTING; BEND UP TO DECREASE VOLTAGE SETTING
CURRENT-REGULATOR UNIT
BEND DOWN TO INCREASE CURRENT SETTING; BEND UP TO DECREASE CURRENT SETTING
CUTOUT UNIT
VOLTAGE-REGULATOR UNIT
BEND DOWN TO INCREASE VOLTAGE SETTING; BEND UP TO DECREASE VOLTAGE SETTING

signed to operate with a particular generator and polarity system. For this reason regulators or relays must never be replaced by others of a different type or model. The only exception to this occurs when the manufacturer supersedes one model with another. If a regulator with the wrong polarity is installed, the result may be a rapid failure of the regulator.

2. Do not close the points on the cutout relay by hand when the battery is connected. To do so will damage the relay points, and by welding them together may cause serious damage to the generator.

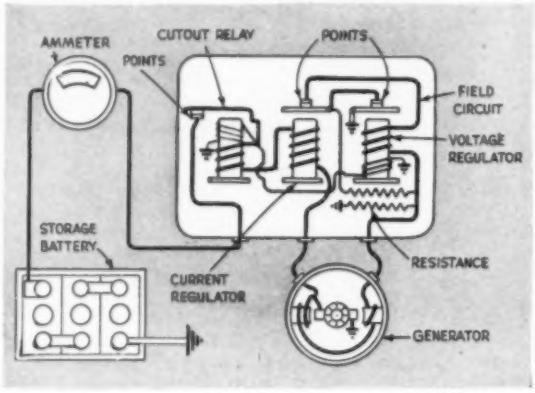
3. A regulator should be at its normal operating temperature when tests are made. If it has been demounted for service, it should also be tested in its normal operating position.

4. After any voltage-regulator adjustment, go through the following procedure before testing the new setting. Replace the cover and reduce the generator speed until the cutout points open; then speed up the motor until high output is achieved.

5. When any adjustment has been made on a regulator, the generator must be repolarized by momentarily connecting a jumper lead around the regulator. This permits a brief surge of current to flow from the battery to the generator. A generator with reversed polarity will cause arcing and burning at the points.

6. If the regulator points need cleaning, use a thin, flat, fine-cut file. Cavities not deep enough to make replacement of the points necessary may be scraped with a spoon file or riffler. The points should then be cleaned with carbon tetrachloride.

It can be readily seen that a regulator should be treated like the delicate precision instrument that it is. Random tinkering with a screwdriver is rarely advisable because it may do more harm than good. If points are clean and all connections are tight, major readjustments will not often be needed. When they are required, the best course is to study the manufacturer's recommended checkup procedure, to make each readjustment singly, and to verify each new setting with an accurate meter.



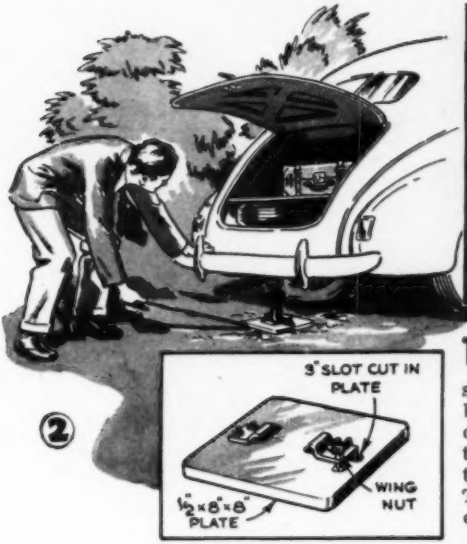
HOW A GENERATOR REGULATOR WORKS

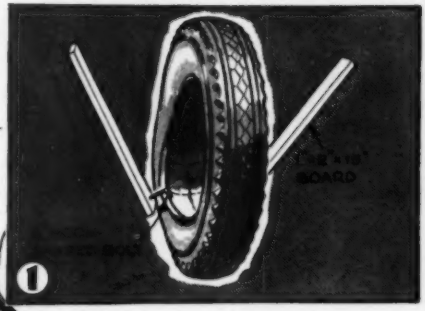
THOUGH seemingly complicated, a generator regulator is not difficult to understand. As the generator picks up speed, voltage builds up in the two windings of the cutout, creating two magnetic fields which together overcome a spring pull and close the points. The battery is then being charged. If the generator output drops off to the point where the current would flow back from the battery, the direction of flow through the heavier winding is reversed whereas the flow through the other winding is *not* reversed. The two magnetic fields then cancel each other and the spring pulls the points open.

The voltage regulator operates on the principle that as a battery nears its full charge, the voltage in the charging circuit tends to increase. This regulator also has two windings; the heavier one is part of the field circuit so long as the points are held together by a spring, while the other carries battery current. As the battery approaches a full charge, the magnetic field built up in the two windings is sufficient to open the points. The field current must then flow through a resistance to the ground; and the magnetic pull in the regulator core is greatly reduced. The points then close again, and the cycle is repeated from 50 to 200 times a second.

In the current regulator there is a single heavy winding which carries the entire generator output. When the generator begins to exceed its maximum rated output, the magnetic field generated by the winding is sufficient to break the circuit, forcing the field current to flow through a resistance to the ground. This weakens the magnetic field, the points close, and the process repeats.

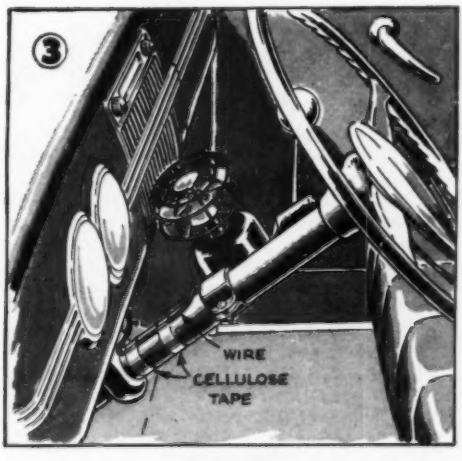
USEFUL AUTO HINTS





1 **TIRE INSPECTION TOOLS** can be made by inserting two 6″ long screw hooks a short distance from the ends of two boards. If these are hooked over the beads of a casing and the ends of the boards are then pulled away from the tire, it is easy to look for breaks, other injuries, or nails. The tools cost little to make and may be conveniently carried in the car.—A. R.

2 **AN AUTO JACK BASE** is handy whenever a flat tire must be changed on a wet, soft, or sandy shoulder where the jack might otherwise sink into the ground. The base is also valuable even on firm ground because it adds to stability and minimizes the chance that the car may fall off the jack. Bolt the two strap-iron clamps to a ½″ metal plate that is at least 8″ square. If you are unable to obtain a suitable metal plate, hardwood 1¼″ thick will serve, provided that it does not raise the jack too high to fit under your car.—H. W.



3 **CELLULOSE TAPE** is convenient for securing loose or dangling wires about the steering column and dashboard. The tape, which is inconspicuous because of its transparency, both removes a minor accident hazard and reduces the likelihood of short circuits or broken wires. It is also excellent for correcting rattles and squeaks of fittings under the dash.—E. M. G.

4 **GASKETS CAN BE HELD** in place by thread when an oil pan (or any other large part using a gasket) is being reassembled. It is often difficult to insert the bolts through the proper holes even when heavy grease or shellac is used as a binder for the gasket. If ordinary sewing thread is looped through alternate holes, the pan can be bolted on easily. Once the bolts are drawn up tightly, the fine thread will not interfere with a perfect seal.—J. K.

Stan pulled into the Model Garage with a spick-and-span sedan in tow of the wrecker

Gus Deals in Opposites

HE PROVES THAT THE SAME SYMPTOMS DO NOT ALWAYS POINT TO THE SAME TROUBLE

BY MARTIN BUNN

IT WAS getting along toward supper time of a warm fall evening, and a half dozen of us Model Garage regulars were sitting around Gus Wilson's shop watching him work, when his partner Joe Clark stuck his head in at the door that leads from the office and said: "Oh, Gus, I forgot to tell you—Alex Kerr called up a little while ago and said he wanted his car towed in. He didn't say what was wrong. I sent Stan for it. He ought to be back any minute now."

Alex Kerr is a mild-spoken, apprehensive-looking little man who runs the cigar store across the street from the railroad station in our town. Gus Wilson and he are about as different as any two men can be, but that doesn't keep them from being firm friends.

Big Ez Zacharias burst out laughing at mention of Alex's name.

"Betcha a dollar there ain't a derned thing the matter with his car," he offered, and took a big bite off a plug of chewing tobacco. "He's worse'n an old woman with that bus of his—every time he hears a rattle he's dead sure his motor's comin' apart. He only drives it a couple of days a month, and I betcha every time he brings it home he washes it off an' polishes it."

Ez chuckled at the thought of Alex shining up his five-year-old bus.

"Why, I met him at the Pleasanton crossroads one day, an' he flags me down an' asks me if the dirt road I'd jest come over was muddy. 'Muddier'n Jason's bog,' I tells him, 'but nothin' you can't plough through.' "

Ez laughed out loud and slapped his thigh with a resounding whack.

"Alex shakes his head," Ez sputtered again after a pause, "and says he guesses he won't try it—he don't want to get his car muddy!"

"Well, Ez," Gus told him, "nobody ever will accuse *you* of taking too good care of your car. Maybe Alex is a little overcareful, but there's no *maybe* about your being overcareless!"

Ez grinned, pushed his postman's cap onto the back of his shaggy head, and shifted his quid over to his left cheek. "I can't afford to baby my automobiles," he said defensively. "I gotta get the mail over that rural route of mine, ain't I? Anyway, cars is

built to take it, and I aim to see that any car I drive goes any place I have to. When I'm deliverin' Uncle Sam's mail, I've got no time to be nursin' and foolin' around with a temperamental car."

A horn honked briefly outside the open shop door, and Stan—he's the Model Garage's current grease monkey—slowly maneuvered the wrecker and a respectable-looking '39 sedan into the shop. Alex Kerr got out of the sedan, looking even more worried than usual.

"Hello, gents," he told the Model Garage regulars briefly but courteously, and hardly waited for a reply to his greeting before jumping right to the point.

"Say, Gus," he said with a rush of words. "I'm in bad trouble. I guess I've stripped a lot of teeth out of my flywheel. That's bad, isn't it—a pretty big repair job?"

"Well, it *is* sort of a big job," Gus admitted. "You have to remove the transmission and clutch before you can take out the flywheel to change the ring gear. The old ring gear must be cut off; then the new ring must be heated to expand it so it can be pressed on the flywheel. It's what's called a shrink fit.

"But before we start worrying about that, let's make sure that we're doing our worrying about the right thing. Flywheel teeth don't get broken off so often. What makes you so sure you've stripped yours, Alex?"

Alex looked relieved.

"Well, it sounded as if I had," he said. "This afternoon I thought I'd go over to Pleasanton to see my sister."

"Ain'cha askeered of that Pleasanton mud hole and of using up your A coupons?" Ez asked, and he looked around at the rest of the boys with a sly twinkle.

"I got a right to see my sister," Alex retorted. "She's been sick in bed for the last month, and, anyhow, I haven't driven my car a mile in three weeks, and I always go easy on my A coupons."

Satisfied that he had justified himself, Alex turned back to Gus.

"Well, when I tried to start up," he said, "there was a terrible noise, and the motor stopped dead almost as soon as it started. I didn't know what was the matter, so I went into Henry Miller's hardware store and asked him. He came over to my garage with me, and I stepped on the starter again. The motor did the same thing—made that noise and stopped almost as soon as it started. Henry said: 'You've stripped some of the teeth off your flywheel—you better not monkey with it.' So I phoned Joe Clark, and he sent the wrecker—and here I am."

WE ALL had to laugh at the idea of anyone who was having car trouble asking Henry Miller's advice—Henry being strictly a Sunday driver and notoriously a left-handed mechanic. Even Gus Wilson had to grin at that one.

"About that noise," he asked Alex. "What did it sound like?"

"Oh, I dunno exactly—it sounded like broken teeth to me," Alex said. He scratched his head. "Wait a second, now—yes, I've got it. The noise was three or four clicks—loud ones."

"Clicks, hey?" Gus said. He got into Alex's car and stepped on the starter. The starting motor took off, but after it had turned the engine over maybe about a quarter of a revolution there was a sharp *click-click-click-click,* and then it stopped dead.

Gus switched off the ignition and got out of the car.

"You can quit worrying, Alex," he said. "There's nothing the matter with your flywheel—none of the teeth have been broken. The only bill you'll have to pay on this job is for the wrecker and for recharging your battery."

"Recharging my battery?" Alex looked incredulous. "What's my battery got to do with it?"

"Everything," Gus told him. "Your battery is so run down that it can't feed the starting motor enough juice to turn the engine over. Those clicks are the tip-off—some types of solenoid-starter relays always

"In the end she always starts off, and then runs all right all day, even on bad roads"

give off a series of loud clicks when you step on the starter if the battery is run down. I'll put a rental battery in your bus now, and you can stop by the day after tomorrow and get yours."

AS SOON as Alex had driven out of the shop Ez Zacharias slapped his thigh with one of his ham-sized hands and let out a bellow. "What did I tell you?" he demanded. "He's just like an old maid with that bus.

"Say, I've been havin' trouble somethin' like his—only I ain't heard any of them clicks. Sometimes when I try to start up in th' mornin' my motor acts th' same way—like broken flywheel teeth was jammin' the starter-motor drive gears. The starter turns the motor over pretty near a full turn, near as I can make out, and then she goes dead.

"But I don't start worryin'. No, sir! I just wait a couple of minutes, and then step on her again. Sometimes I have to do that a half a dozen times, but in the end she always starts off, an' then runs all right all day. First off I thought my battery was run down, but it ain't. Well, cars is built to take it. What's the use of gettin' in a stew every time somethin' ain't just right?"

"You're a wonderful guy, Ez," Gus told him. "I'll bet that car of yours uses mighty little oil, too."

"Huh?" Ez grunted. "How do you know that? I don't generally get down here to town to buy my oil. But you're dead right—I never saw a car that uses so little."

"Ever take a look to see what's in your crankcase?" Gus asked.

"Me? No!" Ez said. "Why should I? Car's runnin' fine, except for that hard startin' some mornin's."

"Take a look," Gus advised. "It might save you some money."

Ez stared at him. Then he got up. "So you figger there's somethin' serious the matter, do you?" he said. "O.K., Gus—that's plenty for me. Wait a minute till I drive it in, and then *you* can take a look."

A half minute later Ez drove his mud-spattered sedan into the shop. "Have you ever washed that jalopy since you bought it?" someone asked when he got out.

"No, sir, I ain't," Ez said shamelessly. "What would be the use—I'd get it all muddied up again next time it rained, wouldn't I?" He turned to Gus. "Go ahead, perfessor—let's see what's in the crankcase."

Gus placed a large can under the car and opened the crankcase plug. A black, pasty semifluid began dripping slowly into the can. Gus rolled a drop of it between his thumb and forefinger. "Sludge," he said. "Much more water than oil. Your crankcase is full of it—that's why you *thought* you didn't need any oil. Man, you've been driving this car with practically no engine lubrication. You'll be darned lucky if you haven't scored your cylinders or your pistons."

Ez was looking serious now. "What do you mean—water?" he growled. "Where would all that water come from?"

"It came from one of the cylinders," Gus said. "The odds are about a hundred to one that it got into the cylinder from the water jacket through a loose or broken cylinder-head gasket, although there is just a chance that it got in through a crack or a sand hole in the cylinder. I'll have to do some checking to make certain, but probably the trouble is a bad gasket."

Ez looked relieved. "Well, that ain't so bad that it couldn't be worse," he said. "Get it fixed up as quick as you can, will you? . . . Say, Gus, how the dickens did you know there was water in my crankcase?"

Gus laughed. "Oh, I just used my head—that's what it's for," he explained. "You said that when you stepped on your starter in the morning—after your car hadn't been used for several hours—the starting motor would turn your engine part way over and then stop; and that after you had waited a while it would give it another part turn; and so on until finally it started.

"That made me guess that your starter motor was working against water in one of the cylinders—water in a cylinder can't be compressed by the piston, but if you continue to apply pressure to the piston it will force the water, little by little, through the ring gaps into the crankcase. The fact that your car was using very little oil was good supporting evidence—naturally, all that water in the crankcase kept the oil level up, although what you were using for lubrication wasn't oil, but watery sludge. . . . I don't think you've done much real damage this time, Ez, but if you keep on misusing your car, someday you're going to get into real trouble."

Ez bit off a fresh chew.

"Who, me?" he said. "I ain't worryin'—not while you're around to worry for me!"

GUS SAYS:

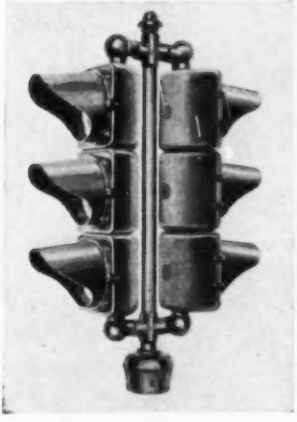
Reduced antiknock in our wartime gas gives the motorists one more thing to watch—but it isn't all bad. Some drivers have discovered that they can cut down on knocking by easing up on the accelerator. And that is a good way to lengthen tire life and increase mileage, too!

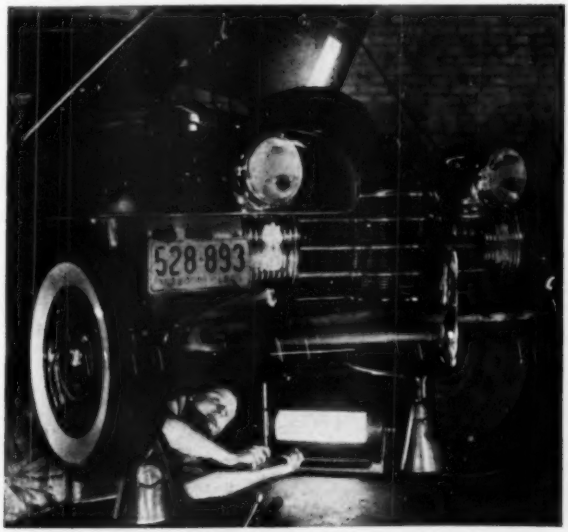
AUTO Ideas

OVERSIZE TIRES are now issued to Army motorcycle units for desert use. The tires, which are mounted on 15" rims, carry only a few pounds of air pressure for travel through sand. Armored Force officers say that they have jumped the motorcycle from the least maneuverable military vehicle in deep sand to the most maneuverable.

The photos above, taken at the Armored Force School, show the new tire undergoing hill-climbing tests and compared to a standard tire. Note the greatly increased road-bearing surface.

PHANTOM RAYS, sun reflections that may make a traffic signal seem to be lighted when the sun is low in the sky, are eliminated in a new type of light shown below. The silvered glass reflector is so shaped as to prevent the reflection of any light except that from the bulb within the signal.



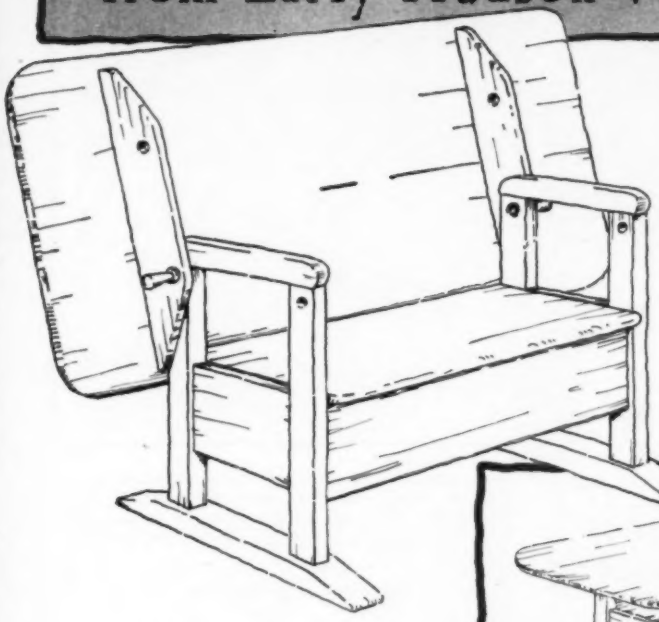


PORTABLE FLUORESCENT lighting units have been developed for use in garages. These utility lamps each contain two fluorescent tubes which are protected from breakage by a clear plastic guard. The lamps may be used on casters under autos or suspended like droplights.

HOME AND WORKSHOP

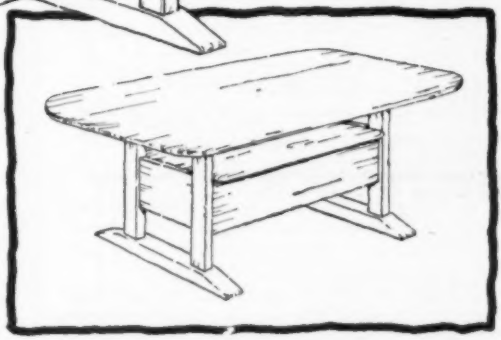
Here is another handsome and useful piece from the workshop of Joseph Aronson, who is well known to readers of POPULAR SCIENCE as a designer of authentic interiors. He developed it from furniture that has been in demand since its introduction by Tudor craftsmen. Duplicated in the home shop, it will serve as table and bench on a terrace

OLD DUTCH SETTLE
from Early Hudson Valley Days



A TABLE, BENCH, AND STORAGE BOX IN ONE WILL MAKE AN IDEAL PIECE FOR YOUR COUNTRY OR SUBURBAN HOME

By
JOSEPH ARONSON



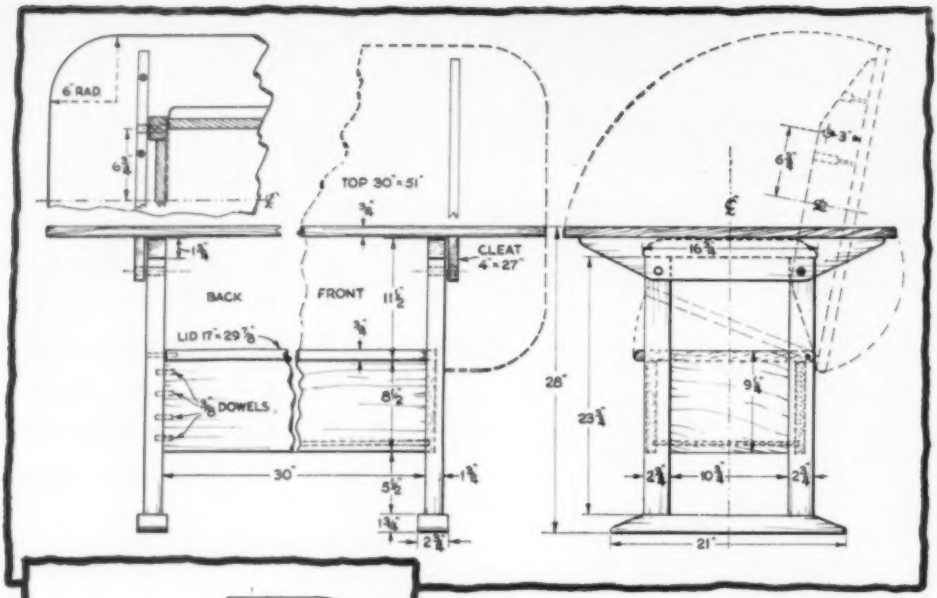
THE box settle or table settle is an old furniture form. Tudor designs of this type reappeared in American furniture of the 17th and 18th centuries, and in simplified versions the settle still appears in country homes up to the present day. The model illustrated was designed for and used on the covered terrace of a modern American home, doubling as table and bench as the occasion required.

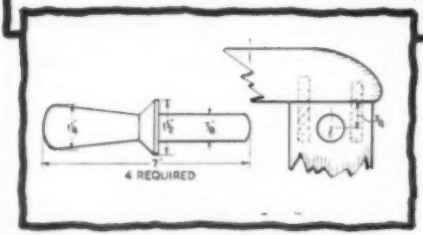
A storage compartment is an authentic part of this piece and accounts for its part-time name of box settle. One other name, Dutch settle, stems from its popularity with the Hollanders who settled in the Hudson Valley. The term "settle" itself has nothing to do with settlers, but is an old word for bench, especially a bench with a high back.

The basic construction of this table settle is elementary, and the materials may be of the average lumber-yard kind. Posts and top stretchers should be selected from the best sections of 2" by 3" pieces of fir or pine, planed and sanded smooth, and then doweled together. Note that the box ends are placed so that their top edges come flush with the top of the box lid, and ¾" higher than the box sides upon which the lid rests. Both ends and sides are fastened to the posts with four dowels at each end.

For the box floor, if ⅜" plywood is not available, ¾" material may be used. Ends and sides of the box are rabbeted to receive the floor, which has its four corners notched out to fit around the posts. The lid should be glued up and reinforced with cleats screwed to the underside. Metal hinges may be used, or dowel pins may be put into the lid from the posts, but be sure to get the dowel centers outside of the back of the box as shown in the drawing.

Material for the top should be selected from clear, straight stock and carefully glued up. Deep cleats, which are screwed on, will help keep the top straight. Pivoting of the top is by means of the turned pins inserted through holes in the cleats into cor-





Front and side views of the table settle, above, show in detail how this triple-purpose piece is constructed, while at left the drawings are of a table-top pin and a doweled stretcher-post joint

responding holes in the posts. The position of these holes must be exact or the top will either rest at a bad angle when up or not set properly on the arms when down.

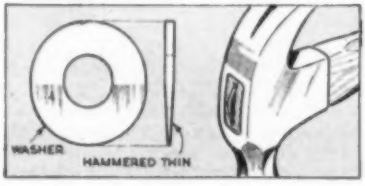
Finish the table settle to suit its intended use. If the wood you use has an interesting texture, a pleasing finish can be made to simulate old pine or maple with a water stain of light walnut color, brushed over when dry with shellac and thoroughly sanded to a satin smoothness. On the other hand, a note of strong color is pleasant for porch or terrace furnishings, and some decorators would be tempted to try strong red, blue, or yellow paint.

LIST OF MATERIALS

No. Pc.	Description	T.	W.	L.
4	Posts	1¾	2¾	23¾
2	Stretchers	1¾	1¾	16¾
2	Box ends	¾	9¼	10⅜
2	" sides	¾	8½	30
1	" lid	¾	17	29⅞
1	" floor (plywood)	⅜	14¼	30½
2	Feet	1¾	2¾	21
1	Table top	¾	30	51
2	Cleats	¾	4	27
4	Pins turned 7" long from 1½" stock			

Note: All dimensions are given in inches.

Improvised Wedge Made of Washer Locks Hammer Head Firmly



A LOOSE hammer head can be fastened securely and permanently to its handle by the use of a wedge made from an ordinary washer. On an anvil or a block of metal, hammer the washer to a thin edge at one side as shown in the drawing at the left. Drive it into the handle as you would a wedge. The compressed wood tends to expand back into the hole of the washer, locking it firmly.—HARRY S. ALLEN.

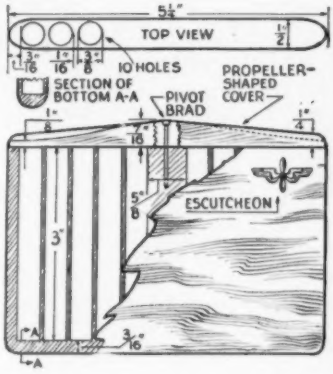
FOR THE BOYS IN THE SERVICE

CIGARETTE CASE

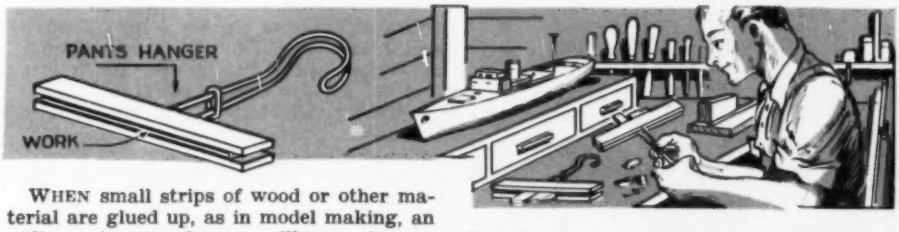
Made from a solid piece of wood, this case will hold 10 cigarettes. Its pivoted lid is held on by a brad and, as a decorative touch, is shaped like an airplane propeller

HAVE you a son or a friend in the Army Air Forces? Here is a simply made cigarette case that will be an acceptable gift. In fact, its airplane-propeller lid lends it a novelty that will make it appreciated by anyone in the services.

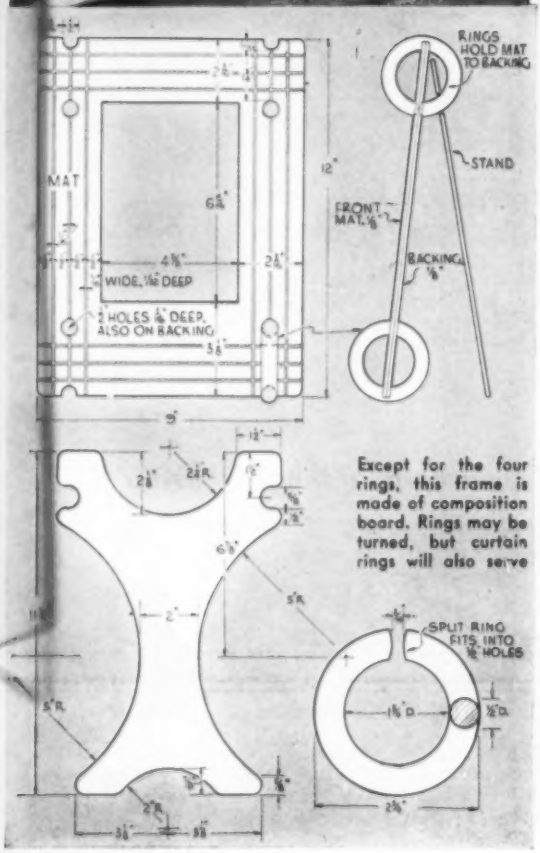
Gumwood, mahogany, walnut, or any close-grained wood is suitable for the case. Shape it roughly to the dimensions shown; then bore the ten cigarette holes—holding a half package of cigarettes—to the size in the drawing, which is just large enough to let a cigarette slip in or out. These holes are best made in the drill press, if one is available. Dress the case to shape, sand, and give it a rubbed-varnish finish. The insignia in the corner which decorates the case is taken from an inexpensive pin.—B. M.



Trousers Hanger Clamps Small Glued Parts in Model Making



WHEN small strips of wood or other material are glued up, as in model making, an ordinary trousers hanger will serve to perfection as a clamp. The device works independently of a fixed axis and will clamp equally well whether the outer surfaces of the pieces are parallel or tapered. These hangers are usually faced with felt, which will be a help in keeping tapered sides from slipping under pressure.—R. E.


RINGS HOLD MAT TO BACKING
STAND
MAT
FRONT MAT
BACKING
WIDE, DEEP
HOLES DEEP, ALSO ON BACKING
Except for the four rings, this frame is made of composition board. Rings may be turned, but curtain rings will also serve
SPLIT RING FITS INTO HOLES

Craftwork

ATTRACTIVE PHOTOGRAPH FRAME

Designed by ERNEST R. DEWALT

EASEL PICTURE FRAME. This interesting picture frame is made of ⅛" hard, pressed composition board, as shown in the drawing. Heavy cardboard glued up could be substituted for the pressed board. The picture opening is cut in the front mat only, while the ½" holes for the rings are drilled 1/16" deep in the front of the mat and in the back of the backing. These holes are lined up to take the rings, which, when in place, hold the mat and backing together.

Make three parallel cuts on the mat on a circular saw for decoration. Cut the easel stand as dimensioned so it will open freely to the proper angle. Rub white paint into the saw cuts, and when it is dry, sand and wax the entire frame. The photo is taped in position on the backing, the mat is arranged over it, and the rings are snapped in place to hold the pieces together. Working time: 3½ hours.

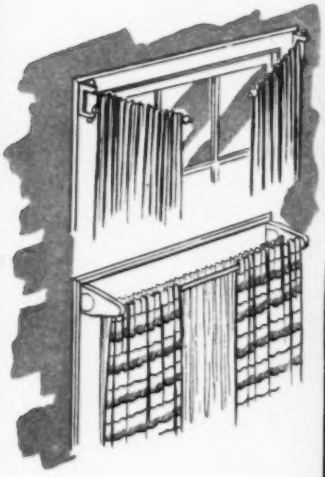
PIVOT CURTAIN BRACKETS OF WOOD. Maple pivot hinges for curtains answer a common household problem in a decorative manner. A pair of brackets and poles swing on dowel pins having beads at top and bottom. The wall mounts are fastened with long screws. Saw out the opening in the mounts, and bore and countersink two screw holes as shown. Fit each bracket in its mount so that it won't bind when swung; then, using a ¼" auger, bore a hole for the dowel pin through both parts when they are lined up.

Bore a ½" hole in the edge of each bracket for a dowel curtain pole. Round and shape the lower part of the bracket, and round the back of the bracket and the front of the wall mount to a 7/16" radius. Turn and drill beads for each dowel pin and the finials for the ends of the curtain poles. The top bead is fixed on the dowel pin with a brad; the bottom bead is removable, but it is a tight fit. Cut the curtain dowel to a length suitable for the width of curtains and size of window. Stain or paint the dowels, finials, and beads any desired color, and varnish or shellac the hinges. Working time: 3½ hours each pair.

DOUBLE WINDOW HANGER. Use maple or some other hardwood for the bracket and circular key, because the joint that holds the weight must have strength. Lay out the

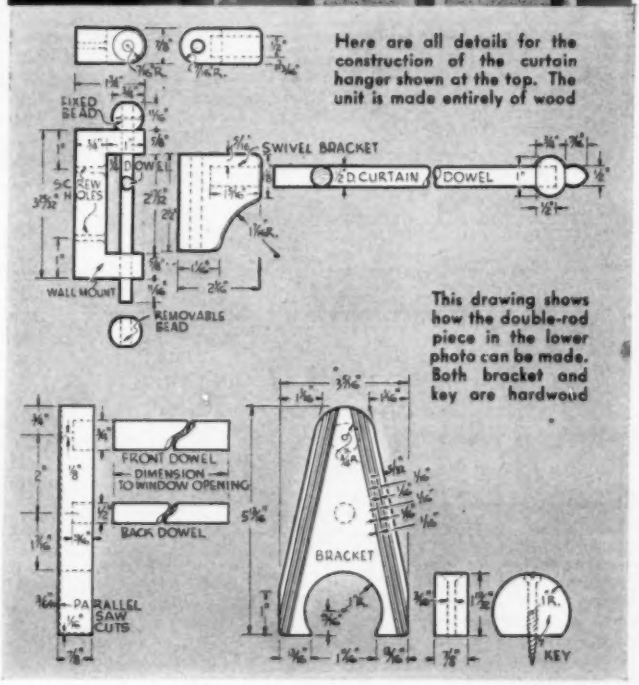
Ideas for the Home

AND TWO WOOD BRACKETS AND RODS FOR CURTAINS AND DRAPES

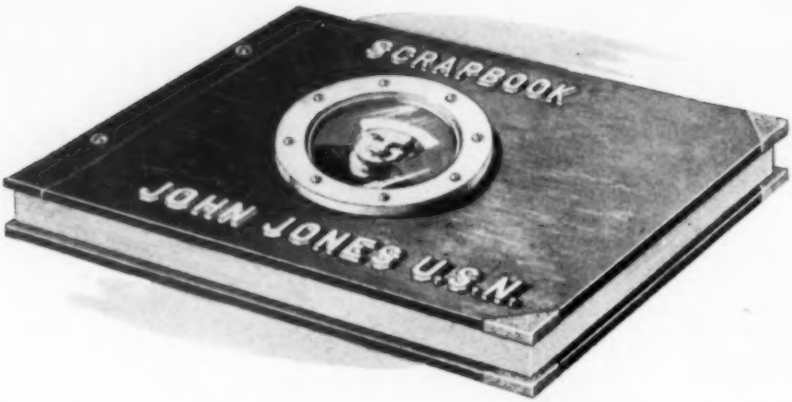


brackets from a center line and make both of them at the same time. Cut out the circles in the base and bore the holes for the two dowel poles. Round the top into the slanting sides and sand smooth. Cut the parallel grooves on a circular saw. Each key is sanded to a slip fit in the curve of its bracket. Bore and countersink each key for a 2⅜" wood screw. Cut both dowel poles to suit the window dimension. The finish should be such that it will harmonize with the color scheme of decorations in the room.

To install, screw the keys to the woodwork, and then slip the curtain hanger, already assembled, over the keys. The weight of window hangings will prevent slipping of the brackets on the keys. Working time: 3½ hours each pair.


Here are all details for the construction of the curtain hanger shown at the top. The unit is made entirely of wood
FIXED BEAD
SWIVEL BRACKET
DOWEL
2"D CURTAIN
DOWEL
SCREW HOLES
WALL MOUNT
REMOVABLE BEAD
This drawing shows how the double-rod piece in the lower photo can be made. Both bracket and key are hardwood
FRONT DOWEL
DIMENSION TO WINDOW OPENING
BACK DOWEL
PARALLEL SAW CUTS
BRACKET
KEY

HW 517



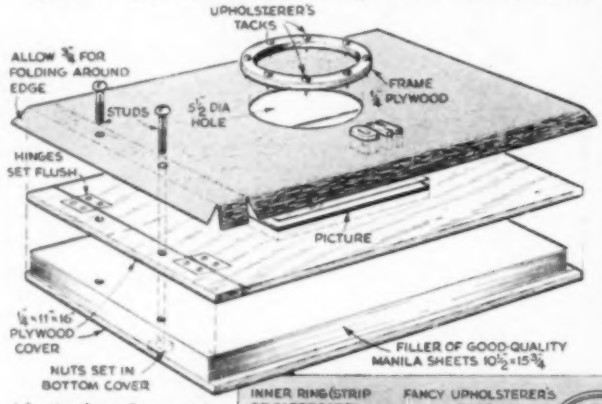
Personal Scrapbook for Mementos from Your Own Hero

ANY family with a member in the service will appreciate a personal scrapbook in which to keep clippings and pictures that are being saved for his return. The covers of this one are made of ¼" plywood, as is also the frame for the cover picture. Saw through the front board 1" from the binding edge and join the two parts with small hinges set flush. Clamp the boards together for accurate alignment and drill two holes for binding posts, countersinking the back for nuts, which are glued in place.

Coat the outside of the back with glue and stretch over it imitation leather, canvas, sailcloth, light corduroy, or other suitable material, allowing ¾" for folding over the edges. Finish the inside face with a piece of stiff paper glued on to cover the edges of the lap.

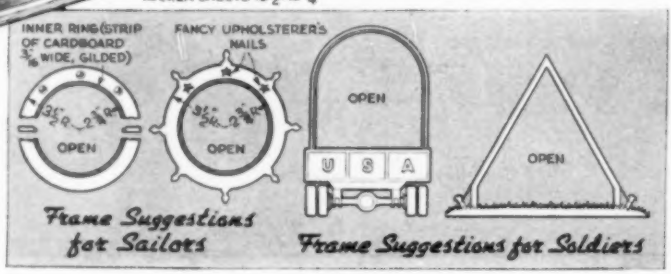
A different treatment is required for the front. Glue the covering material along one edge only, stretch it into position, and hold it with pins. Center the frame for the picture and draw a sharp knife around the inside of the opening; then remove the frame, the material cut out, and the pins. Next, center the picture in the opening, cover it with a thin sheet of transparent cellulose film, and glue the covering material down. Fold the edges and finish the inside face as was done for the back.

Alternative designs are shown for the frame, which may be glued on or fastened with upholsterers' tacks. Red, white, and blue, olive drab, or Navy blue paint may be used for a finish if the material used for the cover is such that it will take paint readily.—JOHN J. GALLIVAN.



Method of Assembly

Alternative frames for the scrapbook cover are shown at right. Use ¼" plywood except for the truck axle, which may be thinner. Any printing serves as a pattern for letters of 1/16" stock



Frame Suggestions for Sailors

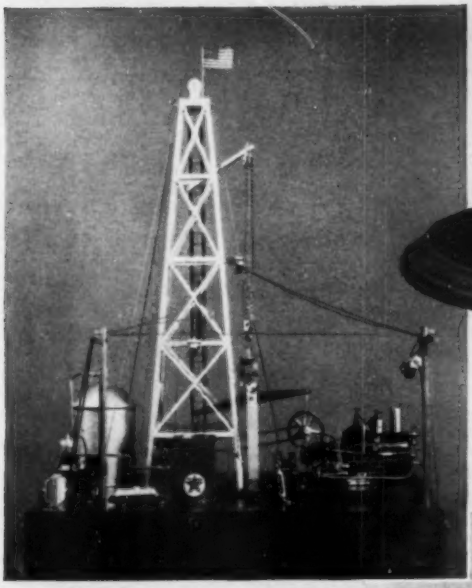
Frame Suggestions for Soldiers

from

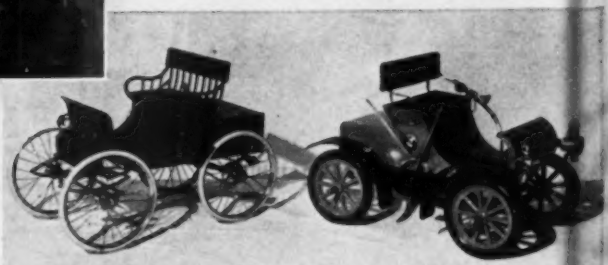
READERS' WORKSHOPS

. . . ACTION MODELS DISPLAY INGENUITY OF HOME CRAFTSMEN

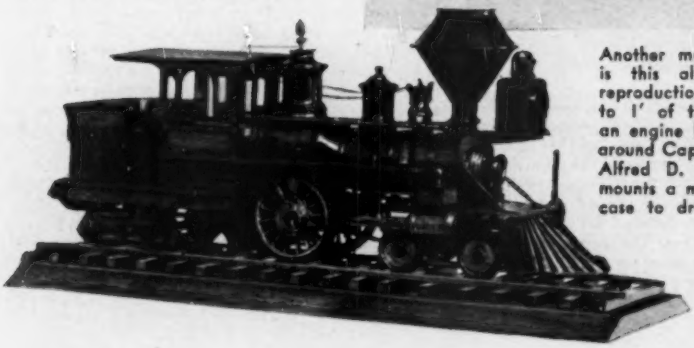
Capable of firing blank .32's, this deck gun has a 12" long barrel, ¾" recoil, 360-deg. traverse, 60-deg. elevation, and adjustable sights. It was built by Fred Jameson, Jr., of Omaha, and M. C. Gentry, of Detroit



Real oil is pumped by the miniature well above, which is modeled after an old-style, steam-driven rig. A 1/20-hp. motor in the base provides power for a continuous flow through ¼" pipe to a tank and return line. Joe D. Kitchen, of Caro, Mich., the designer, even included floodlights



Part of a collection of 50 models built by J. N. Halsted, of Omaha, over a period of 10 years, the two automobiles below depict a phase in the evolution of transportation. At the left is an 1898 Oldsmobile; at right, the same make dated 1903. Each is 9" long



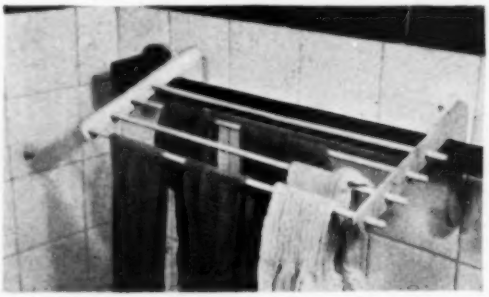
Another model of historic value is this all-wood locomotive—a reproduction on a scale of ⅜" to 1' of the C. P. Huntington, an engine built in 1864 and sent around Cape Horn on board ship. Alfred D. Slater, of Cleveland, mounts a motor behind a display case to drive the working parts

DEHYDRATING IN ANY OVEN is now simple with a new home food drier that can be used to advantage through the growing season and into late fall. Three galvanized-wire racks hold 6½ to 10 lb. of food at one time. The unit measures 11" by 14½" by 17½", which is a convenient fit for most ovens of moderate size. Attached to it is a long, hooklike arm which can be adjusted to hold the oven door ajar for air circulation as drying goes on

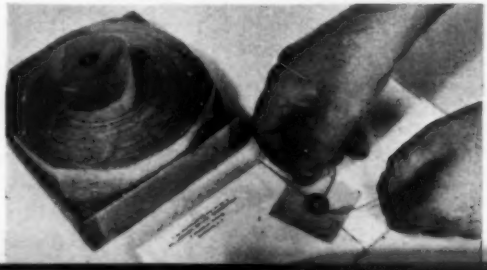
THIS HANDY TOOL is made strong enough to open wooden cases and tough corrugated cartons. Besides this, the blade end of it can be used to cut cord and rope. The carton opener, as it is called, is 14" long and 1⅜" wide and has a specially shaped slot in its flat handle which can be used for pulling out nails in wooden cases. The slot is also handy for hanging the opener up when not in use. The blade is of good steel and can be sharpened on an emery wheel or a whetstone

GUMMED STICKERS that take the place of metal paper fasteners in home or office are sold in convenient sheets bound in booklet form. Each booklet contains 500 gummed stickers. The sheets are perforated to tear apart easily and quickly. Being gummed on both sides, they can be used for attaching carbon copies to letters and for mounting photographs, clippings, and souvenirs in your scrapbook or on file cards, labels on bottles, and like purposes

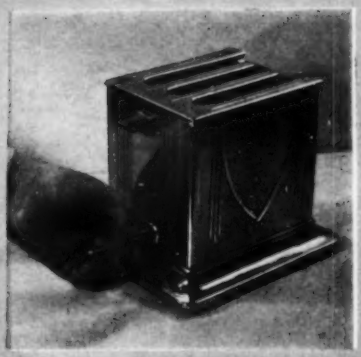
DRYING SMALL ARTICLES in the bathroom involves less trouble if the rack shown below is at hand. Hooked over the towel bar, it will still permit use of the latter while itself providing about four times as much additional space for hanging stockings, handkerchiefs, lingerie, and similar light laundry. Made entirely of wood, it can be put up or taken down in a moment, and holds securely in position without any other fastening



PACKAGED STRING TIES have recently appeared on the market as substitutes for rubber bands. They consist of a stiff paper square with an extra heavy disk to which a length of strong string is fastened. The ties are boxed in the form of a coiled strip having perforations which make it easy to tear off individual ties as needed. Each coil contains 250 ties. Wrapped around papers, envelopes, and small packages, the ties hold securely. They can be saved after use and put into service again and again



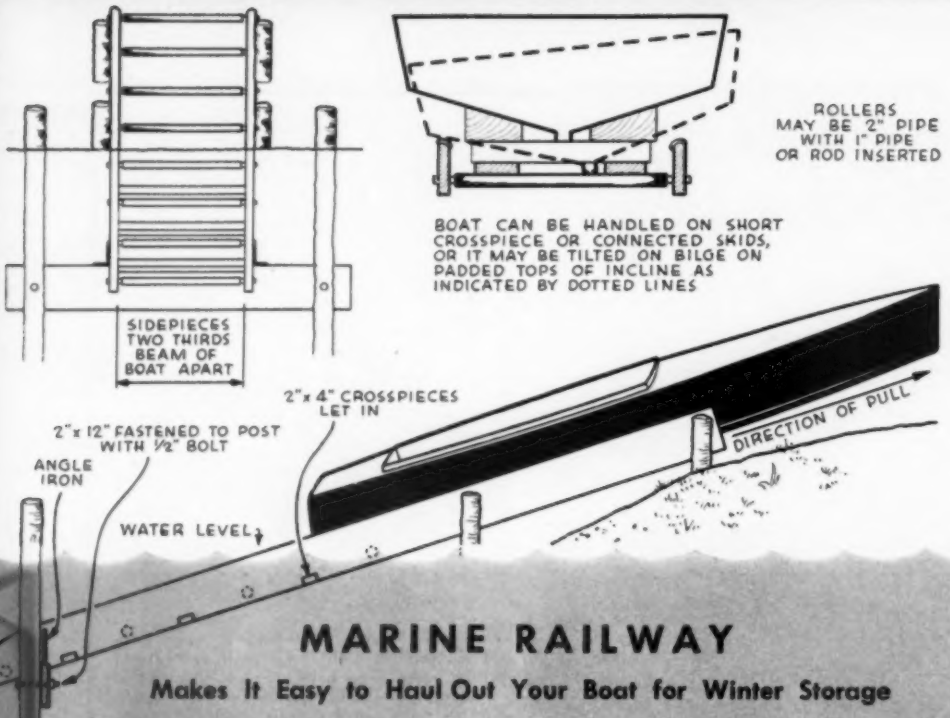
AIDS TO WARTIME *Housekeeping*



CARE OF YOUR TOASTER is wise practice these days, for in most instances it will be impossible to replace it. Clean crumbs out of the inside frequently with a soft brush. If the toaster has a removable crumb tray, take it out often for cleaning. The chrome-plated outside housing can best be cleaned with a damp, soapy cloth, then rubbed briskly with a dry, soft cloth. Never put the toaster in water. Be extremely careful during all cleaning not to damage the heating elements. After using the appliance, allow it to cool off before you wind the cord loosely around it. This will lessen the risk of short circuits that might come from repeated coiling

RESLICING PRESLICED BREAD is made easy with this wooden gadget designed and hinged like the cover of a book. A slice of bread is placed between the two covers and held upright while a knife is drawn down through it to make two thin slices. The covers permit holding the bread firmly without danger of cutting the hand. Any knife with a sharp blade is used. Besides making thin slices for Melba toast, canapés, and rolled sandwiches, the unit is a help with the last end of a roast or meat loaf

PERSONALIZED LABELS are a new idea in identifying jars for families who raise and put up their foods. The labels are attractively colored and are printed with the name of the purchaser. They come gummed on one side and, measuring 2⅜" by 4", will fit any jelly or canning container. There is a space in which to write the name of the contents and the date. These gay labels will add a bright touch to the fruits of your labor, and they will also be welcome presents for a friend who puts up food



MARINE RAILWAY

Makes It Easy to Haul Out Your Boat for Winter Storage

THE incline of this easily-built marine railway is made of two planks set on edge. They must reach out to water deep enough to float the boat, and the rise should not be over 4" to 1' of length. Space the planks roughly two thirds the beam of the boat apart, fastening them with crosspieces let into their lower edges and secured with lag screws.

Rollers can be made of pieces of 2" pipe turning on longer 1" pipes or heavy rods which are fixed in the planks about 3' apart. The shape of the bottom of the boat should be taken into consideration in locating the rollers, especially in fixing the distance from them to the top edges of the side planks. Medium-sized boats can lie over slightly until one bilge bears on the top of the adjacent side plank. There will be little pressure when the hull is still water-borne, but above the water the edges of the side planks should be rounded and padded with old hose or canvas, and well greased so as to minimize friction.

Cut notches 2½" wide by 3" deep in the under edges of both side planks about 1' from the ends to be submerged. Fit a plank across two posts, as shown in the drawings, with one bolt only in each end. The posts should be 2' wider apart than the beam of the boat. Drive the posts far enough off shore so that the cross plank can be 2' below the draft of the boat. The single bolt in each end of the cross plank will prevent excessive strain from developing while the posts are being alternately driven into position.

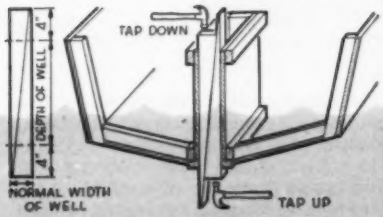
Float the assembled incline out over its location between the posts. Place rocks on it to submerge it so that the notches slip over the crosspiece, then fasten it there. The easiest way to do this is with strap-iron angles previously bolted on the two side planks just above the notches, each with a hole in its horizontal leg. Spikes can then be driven through these holes into the crosswise plank and bent over to hold the incline down. If necessary, you can submerge in a bathing suit and strike a few blows at a time. This fastening is merely to offset flotation, and can easily be released for hauling the railway ashore after the boat is taken out at the end of the season.

The inshore end of the railway is held securely in place by short posts. Sections can be added to extend it as far as desired. The same incline can even be carried high enough so that a truck can be backed up to the end of it and the boat slid aboard and hauled away for winter storage elsewhere.

No great power is required for hauling because of the rollers, although a block and tackle may prove helpful. Fasten the hauling gear to a heavy line looped completely around the hull and held with lighter lines across the top of the boat. This distributes the strain evenly throughout the hull instead of applying the entire load to a single mooring bitt and cleat.

BOAT HINTS

ONE OUTBOARD MOTOR used as shown above saves gas, carries twice as many passengers, and minimizes the danger of a spill in rough weather. The two canoes are held rigid with saplings lashed to the thwarts.

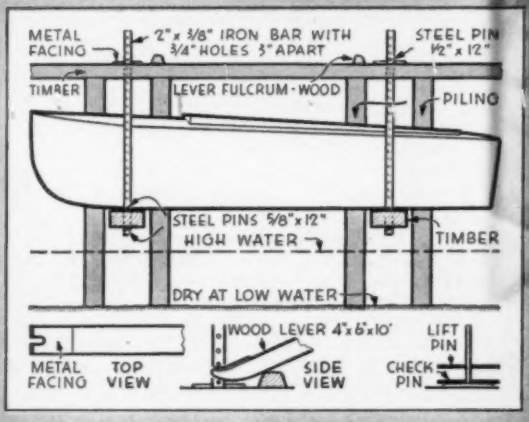


A WARPED TRUNK makes it hard to raise or lower the centerboard. To correct this condition, insert wedges at the center of the well as at the left before the boat is laid up for the winter, and leave them in until spring. Have a helper tap in one wedge while you drive in the other, being careful to expand the slot only slightly beyond its normal width.—H. S.

SMALL-BOAT DRY DOCK. Costing no more than a few dollars, this arrangement makes it easy to lift boats clear of the water for repairs or painting. Small boat yards and clubs, as well as individual boat owners, will find that it pays for itself quickly. The dimensions of the various parts will vary according to the size of the slip and the length of the boats to be accommodated. Those up to 30′ in length can be raised in the dock shown at the right.

One man can readily lift a boat by means of the 10′ long lever. This is hooked down to the dock at the end of its stroke so that the operator can then remove the pin which has been bearing the load in order to insert it in the new position. All four lifts should be raised to the same height before the first one is raised any further. The fork end of the lever is protected by covering it with sheet metal at the points where wear would otherwise occur.

If such a dock can be located high enough on tidewater, it is possible to make repairs to the bottom of a boat while standing on dry land. Away from tidewater, the top of the slip should be high enough above water level to give sufficient space for one to work conveniently on the bottom of a boat from a dinghy or wherry.—BRUCE MACINTOSH.



MAINTAINING HOME DEFENSES

A FIRE extinguisher is a front-line weapon against fire. But, as with other weapons, its effectiveness depends on its ability to do the job for which it was designed, on its upkeep, and on the skill with which it is used.

Only three types are ordinarily found in residences. One, the soda-acid extinguisher, will combat fires fed by ordinary combustibles, such as wood, paper, and textiles, but not those involving inflammable liquids or electrical equipment. Another, the foam type, can smother a gasoline or oil fire, but must not be used on electrical apparatus.

The third—the familiar pump-gun vaporizing-liquid extinguisher—employs a carbon tetrachloride base instead of water and may be used on any kind of fire, but it is rarely made in very large sizes. On coming into contact with heat, the stream from this extinguisher breaks down into a vapor that displaces oxygen and thus smothers the fire. This vapor is a nonconductor, will not damage mechanical or electrical installations, and leaves no residue.

All of these units should be inspected at least once a year. The hose, gasket, nozzle, outer shell, and seams should be examined for signs of clogging, corrosion, denting, or tampering. If repairs are needed, they should be made by the manufacturer.

The soda-acid and foam extinguishers also require annual recharging, which can be done at home, preferably outdoors. Directions on the labels should be carefully followed, utensils should be dry and clean, and only refills recommended by the maker should be used. If you mark the date of maintenance on a tag attached to the handle, this will serve as your reminder each year.

Despite its designation as a "chemical" extinguisher, the soda-acid unit uses only water to put out a fire. The chemicals provide pressure to throw the stream 30′ to 40′. This pressure is supplied by carbon dioxide gas formed by the reaction of sulphuric acid with bicarbonate of soda when the extinguisher is inverted for use.

After the unit has been emptied to take its annual recharge, unscrew the ring-top handle and remove the acid bottle; then wash all interior parts thoroughly with clean water, draining the water through the hose. Dissolve the powdered chemical refill in warm, not hot, water, as directed on the label; pour the solution into the extinguisher to the point marked; and finally replace the acid bottle in its cage. When the cap is screwed back on the shell, make sure that at least four threads are engaged. A small amount of petroleum jelly rubbed on the threads will make this easier and facilitate removal for the next recharge.

The foam extinguisher looks like the soda-acid unit, and its parts are handled the same way when it is recharged. If you have any doubts about the kind you own, the Underwriters' rating on the label will identify it. The soda-acid type is rated *A* (for use on ordinary combustibles), while the foam is rated both *A* and *B* (the *B* meaning for use on inflammable liquids). Two chemical solutions must be replaced in the foam-type unit—one in the inner chamber and one in the outer. Directions on the label should be followed, and only the materials recommended should be used.

Vaporizing-liquid extinguishers are the easiest of all to service since they need recharging only after use, but the pump action should be tested annually by discharging a portion of the liquid into a clean dry con-

AGAINST FIRE

Extinguishers Must Be Ready for Instant Action . . . Here Is How and When to Service Them

By

DELBERT JOHNSON
Safety Research Institute

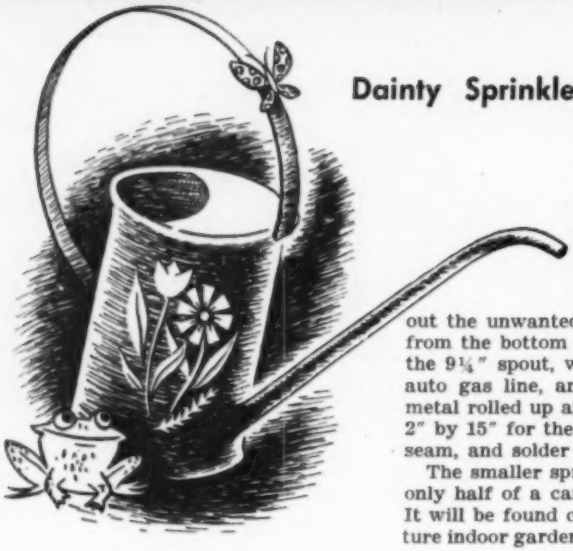
tainer. This test liquid can then be poured back through the filler opening. No lubricant should be used on the piston. Because ordinary commercial carbon tetrachloride may corrode and damage the extinguisher, use only the maker's processed refill.

Soda-acid and foam extinguishers located on a porch, in a garage, or in any exposed place should be housed in a tight cabinet that can be heated by a 50-watt bulb to keep the water from freezing—don't try to use an antifreeze chemical. A simple cabinet of ⅞" stock will suffice unless you live in a section where temperatures go below zero, in which case double-wall construction is needed. For this, make the outer walls of ½" stock, and arrange a lining of ½" wallboard or similar material, leaving a ½" air space between the the two walls. The door should also be of double construction, closing into a rabbet and held shut with a spring latch.

Inside dimensions may be as small as practicable just so the extinguisher may be removed quickly. Four 4" iron rods, or similar brackets, set in the sides about 4" above the floor will hold the unit. Under them should be mounted a 3" conduit box and receptacle for the lamp, which will then throw its heat upward and thus keep the entire cabinet warm. During a protracted freeze, or in subzero weather, the lamp should be kept burning continuously.

Extinguishers of the soda-acid type must be recharged once a year. The chemical is dissolved in warm water and poured into the unit; then the acid jar is put back

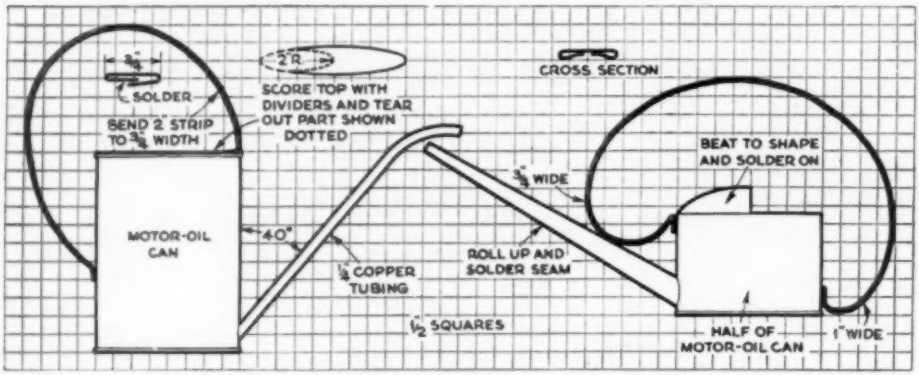
Two chemical solutions are changed annually in a foam-type extinguisher—one being used in the inner chamber and one in the outer. Be sure to replace the cap on the inner chamber securely to prevent the premature mixing of the solutions. A thorough cleaning job should be done on both this and the soda-acid extinguisher at the time of any recharging, and all parts should also be inspected and tested to assure good performance



Dainty Sprinklers Made from Oil Cans

WHEN plants are brought indoors for the winter, you will want one of these sprinklers made from regulation motor-oil cans. The larger one, built from an ordinary quart container with the top left on, holds enough water for several pots. For the opening in the top, score the metal deeply with dividers and tear out the unwanted part with pliers. Punch a hole ¾" from the bottom on the opposite side for soldering on the 9¼" spout, which can be made from a discarded auto gas line, any ¼" tubing, or a strip of tin-can metal rolled up and soldered. Cut a strip of the metal 2" by 15" for the handle, bend it as shown, solder the seam, and solder it to the can in two places.

The smaller sprinkler is made similarly except that only half of a can is used and the top is soldered on. It will be found convenient for small pots or a miniature indoor garden.



NOVEMBER CHECK LIST [*SHIPSHAPE HOME*]

1. Inspect radiators for leaks and repair them with iron cement.
2. Drain a hot-water or steam system and refill with fresh water.
3. Scrape and cement joints in the fire pot of a hot-air furnace.
4. Repair or replace defective furnace grates.
5. Clean soot from the nozzle and burner unit of an oil-heating system.
6. Renew deteriorated smoke pipe from furnace to chimney.
7. Clean out scale and soot in boiler and tubes.
8. Insulate between chimney and wood framing with mineral wool.
9. Cut off water from all outdoor fixtures, such as sill cocks, and drain them.
10. Calk all cracks in the basement where air leaks in.

POPULAR SCIENCE MONTHLY SHOP DATA

For Pocketknife Whittlers . . .

ROCKING-HORSE BLOTTER

Is Fun to Carve

By ELMA WALTNER

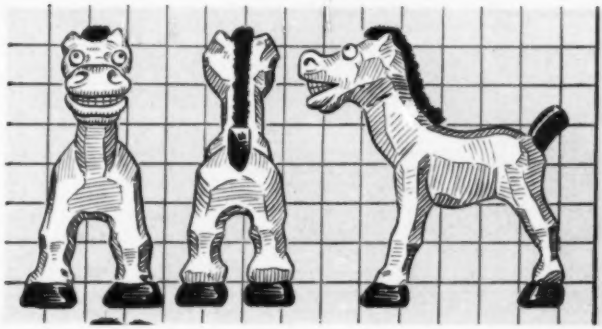
MEET Hector Hobbyblot, a wooden (but not Trojan) horse whose happiest moments are spent riding hobby-horse fashion on unblotted ink or in standing stanchly atop a stamp box. A jackknife job, Hector is well within the capabilities of inexperienced carvers.

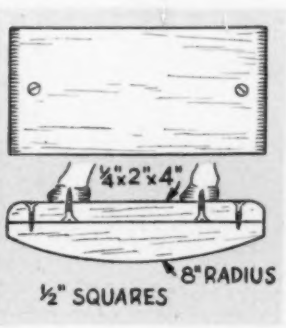
Use any kind of wood you prefer, so long as it's easily worked. Lay out the profile pattern on a piece of 2" stock, with the grain vertical to give sturdy legs. Then cut out the profile and drill two or three holes between the front and rear legs to help remove extra wood.

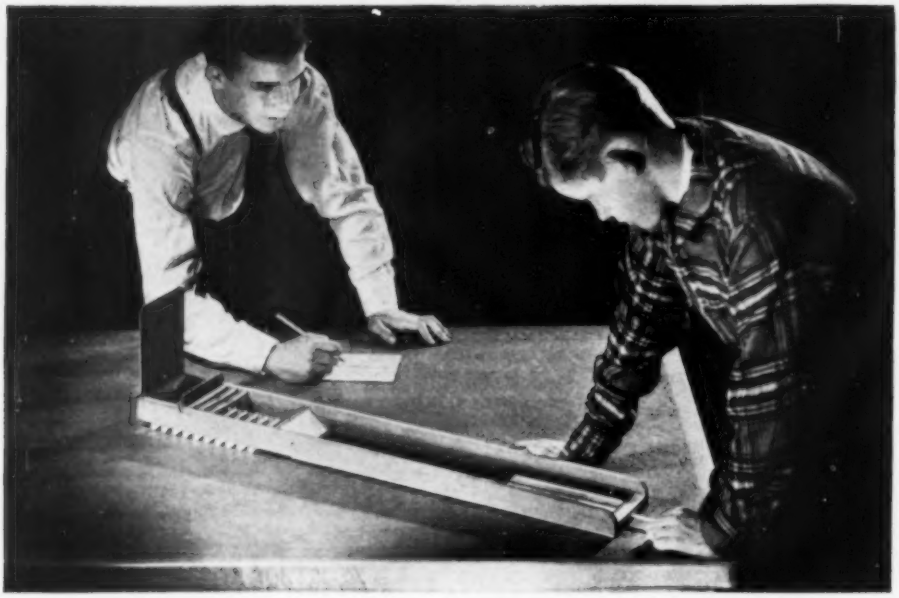
The carving is done entirely with a sharp knife. Don't try for fine detail, since the angles and planes add to the attractiveness of the piece as well as making the carving easier. To insure proper proportioning, turn the work often in your hands and rough out the entire figure before finishing any part. Use sandpaper sparingly to preserve planes.

Finish all but the teeth with shellac; they are a gleaming white, with markings added by pen and India ink. Hector's eyes are white map pins painted with black pupils. His crowning glory, his coal-black mane, is achieved by drilling a row of small holes in his neck and gluing in tufts of black yarn.

For a blotter base, cut one piece of stock ¼" by 2" by 4" and one ¾" by 2" by 4". Round off the ends of the thinner piece and mount the figure on it with four small countersunk screws running from the underside to each hoof. Drill the hoofs first to prevent splitting. Shape the lower section of the base to a curve of about 8" radius and attach with two small screws running down from the upper section of the base. Use strips of blotter cut 2" by 6". If you wish, Hector and the upper portion of the base may be mounted on a stamp box.





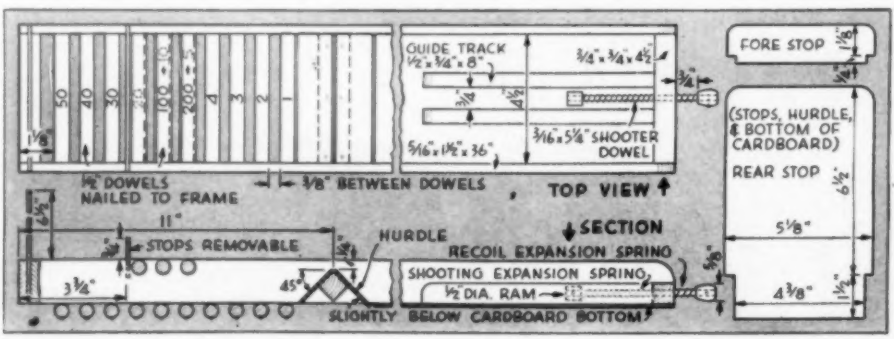


Test Your Skill with This New Double-Deck Skip-Ball Game

IF YOU pull the shooter back just right and release it with a steady hand, your first count may be 200. But if your technique falters, your next count may be a lowly 5. The game is played by shooting balls against the hurdle with just the proper impetus to drop them between the high-scoring dowels. Your turn at play consists of five shots.

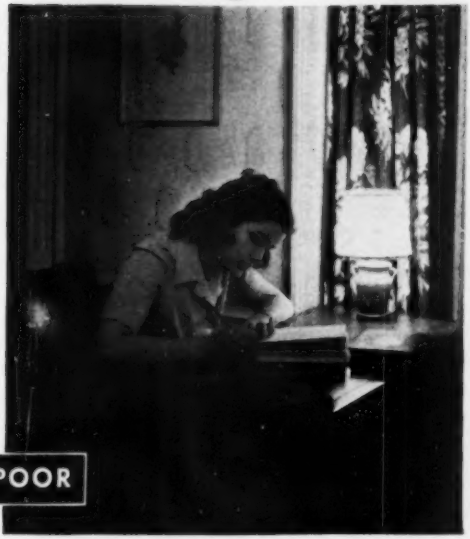
The dowel nearest the player, in the bottom row, is numbered 1. The next nine dowels are numbered, in order, 2, 3, 4, 5, 10, 20, 30, 40, 50. Each number refers to the space in which a ball may rest between it and the next dowel behind it. Dowel No. 50 is ⅜" from the end of the box. The upper three dowels have two scoring spaces, the forward one counting 200, and the rear space 100. Scoring here takes practice and skill. The five balls are wood, ⅝" in diameter.

The model of the game shown in the photograph is attractively painted in five colors. The cardboard bottom and both removable backstops are blue. The sidepieces, the two backboards, and the hurdle are red. Bright yellow covers the guide tracks, front endpiece, shooter dowel, and 10 lower dowels in the scoring area. The top scoring dowels and the ram on the end of the shooting dowel are green. Scoring numbers are lettered in black on the upper surfaces of the scoring dowels.—MYRON FLEISHMAN.



how to get

Better Light from Your Home Lamps



Poor lighting from a small lamp can be corrected very easily by adding an extension base and by replacing the shade. The extension shown above is made principally from a mailing tube

How raising the lamp and increasing the shade diameter give better light dispersal is illustrated at the right

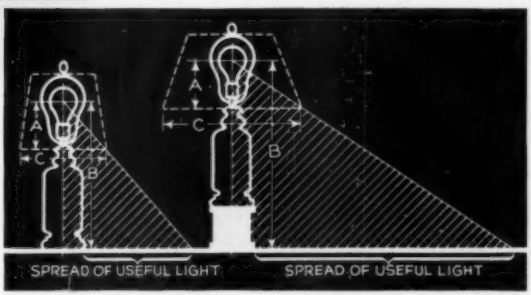
MANY a small electric lamp looks attractive in the store, but when you sit down to read or work by one, you may find that it is better to look at than to see by. Often the lamp is too stubby and the shade too small for proper lighting. Instead of discarding the lamp or putting up with poor light, specialists at the General Electric lighting research laboratories advise, simply make an extension base and use a shade with better proportions. These two steps will result in a substantial increase in the circle of useful light.

The extension base shown in the lower photo is a heavy mailing tube fitted with a turned-wood footing and filled with pebbles for weight. It has a cover recessed about ½″ to hold the bottom of the lamp. A small notch in the lip permits the cord to come out. An attractive extension base may also be turned wholly of wood in a design harmonizing with the lamp and bored all the way through for a wire entering at the bottom.

Lighting experts say that a single-socket table lamp, with its recommended 100-watt bulb, should afford comfortable seeing within a 24″ radius of the base. Whether or not this coverage is achieved, however, depends upon dimensions *A*, *B*, and *C* in the drawing. A squat, tightly shaded lamp has a relatively small useful light circle.

If *B* is lengthened to from 13″ to 17″ by an extension base and *C* is increased by a larger shade, the maximum useful dispersal can thereby be obtained. *A* should be as small as practicable, with the lower edge of the shade, viewed at eye level, covering at least part of the socket.

To obtain efficient reflection of light, use a shade that is lined with white. It is also desirable to select one that is fairly dense so as to reduce direct transmission of light to the eyes.



DIRECT PAPER NEGATIVES MAKE ARTISTIC PRINTS...

This original negative was made with paper in the camera instead of film. An extra-thin grade of single-weight paper was used here

PHOTOGRAPHY

Filmless Photography

SHOOTING NEGATIVES ON ENLARGING PAPER IS GOOD FUN AND WILL BRING REAL RESULTS

EXPERT photographers desiring to produce highly artistic and dramatic photographs have long used the paper-negative process. This consists of making a positive print from a film and retouching it, and then making a negative paper print from the positive for further retouching, after which a finished photograph is finally secured by a print or enlargement made from the paper negative.

Without going through all these steps, and without using film at all, you can get just as fine results. You can make your first negative on enlarging paper in your own camera, and work directly on that, printing your final positive from this lone negative. It is a simple process and is a lot of fun. Enlarging paper is much cheaper than film, and by using it instead of film, you eliminate expensive waste on questionable shots and can also make a lot of pictures you might otherwise pass up because of the cost.

And not to be overlooked is the opportunity to do really thorough and artistic jobs of retouching. Working on a paper negative, the camera enthusiast has a chance to try many effects, rubbing out those that prove least desirable, altering high lights and shadows, and finally bringing the nega-

Either contact prints or enlargements may be made from the paper negative, which may be retouched for special effects

By KONRAD CRAMER

with Your Own Camera

tive to perfection, confident that erasures, pencil marks, and the like will not show up on the finished print.

Probably still more satisfying is the fact that you can know the results of your picture taking within a few minutes of snapping the shutter, for the whole photograph is unfolded for you as you develop the paper negative. As soon as it is dry, if the shot was a good one, you can begin retouching the paper negative to bring out desired effects, and then print your positive photograph from this negative.

To use this type of direct paper negative, cut the enlarging paper to fit in the back of your camera. Loading is similar to that of plate or film-pack cameras, but only one paper negative can be loaded at a time. If you have a roll-film camera, cut the paper for single negatives and load as you would for the other types. It is not always necessary to do the loading in a darkroom, but a subdued red-orange light is essential.

For best results in taking these pictures, use single-weight, soft paper and expose it under strong light. The larger-size cameras, 3¼" by 4¼" and up, are ideal for this method. For my own purposes, I use lightweight paper in an 8" by 10" studio camera with which I can get a negative that requires no enlarging. Add to your equipment two or three photoflood lights, and you can make portraits of unusual quality if you can find a model who will hold still for 10 to 15 seconds. This exposure is usually necessary to get a good paper negative. If a comfortable pose is selected, most people can sit still that long with little trouble.

Still life is ideal material for direct paper negatives. Landscapes, with or without

Dramatic silhouettes with high lights and deep shadows for both figures and background, as shown in the photograph above, are created by retouching both sides of a paper negative before it is contact-printed or enlarged as desired

Portraiture of distinction is possible on paper negatives if the subject will hold a pose for as long as 13 seconds

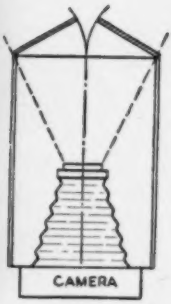
figures in the foreground, are also good. Sometimes you will find that the negative itself has great pictorial charm. In such a case, there is nothing to hinder you from mounting and exhibiting a negative.

The paper negative can be retouched on both sides, using a ground glass and light when working on the back. Light tones, modulations, and additions may be added by building up the wanted values with any soft pencil or crayon and then shading with a stump. Large areas may be handled with a bit of chamois and powdered crayon. Dark tones and accents in the final print can be produced by lightening parts of the negative with local reducer or by carefully rubbing them down with powdered pumice. Major blemishes and faulty backgrounds can thus be corrected.

Some photographers using this process content themselves with only a slight softening of the image, caused by the printing light having to penetrate the paper instead of transparent film, plus a few slight retouching corrections. It seems best to go easy in the beginning so that most of the original character of a photograph is retained. Overworked paper negatives may take on the final appearance of a poor drawing, a result that is to be avoided.

Paper negatives can be enlarged or contact prints made from them. Extra-thin paper should be used in the smaller cameras as it gives a very pleasing texture effect when enlarged. The general effect of the enlargement is diffused, in contrast to the sharp definition of contact prints, yet the enlargement often has simplicity and distinction.

The writer made an 8″ by 10″ cardboard camera, using an ordinary magnifying glass as a lens, two cartons telescoping into each other, and a piece of ground glass which is interchangeable with a printing frame. If you make up such a camera for yourself, you'll be set for some inexpensive and distinctive photography, for paper negatives afford many ways in which to achieve a controlled artistic effect.

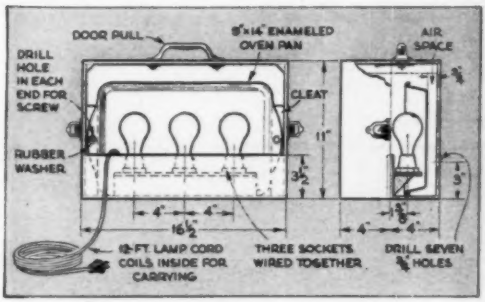


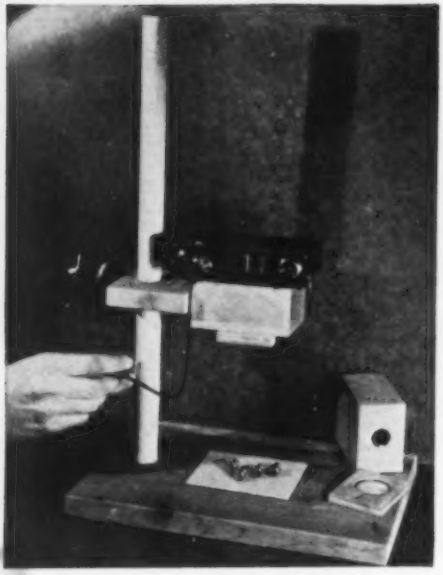
NIGHT AND DAY can be dramatically portrayed in the same picture by using a simple duplicator attachment. Build a box that can be secured to the front of your camera, fitting it with two vertical doors. Aim at a scene that will afford interesting day and night contrast and take, say, a daylight picture with one door closed. Leave the camera untouched until nightfall; then open this door and close the other to make a second exposure on the same film. With a film-pack camera, just block off half the film with cardboard inside the camera, and reverse it between shots.—LOUIS HOCHMAN.

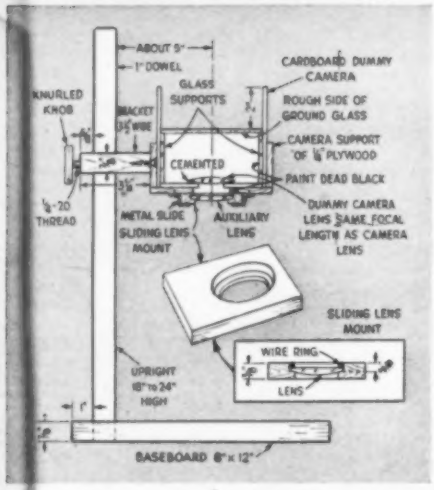
PORTABLE FLOODLIGHTS. Good indoor pictures require adequate lighting, particularly if color film is used. Shown at right is a compact case, only 8" by 11" by 16½", which holds six photofloods, complete with reflectors and extension cords. The case divides into two three-lamp banks of No. 1 photofloods which can be used separately on the floor or on tables or can be hung from picture molding.

As shown in the drawing, the cases are made from thin wood and the reflectors are ordinary white enameled oven pans, fastened to cleats inside each case. Sufficient air space should be allowed so that the cases won't get too hot. Air holes are cut behind the pans to provide ventilation.

In using the outfit, remember that six No. 1 photofloods will load a 15-amp. circuit to capacity. The 18-gauge extension cords should always be plugged into wall outlets, never into lamp sockets.—PAUL KOMROFF.







DUMMY CAMERA

Focuses Copying and Close-up Shots

AN INGENIOUS copying and close-up outfit, especially suitable for roll-film cameras which lack ground-glass focusing, may be built of wood scraps, a ground glass, and two lenses.

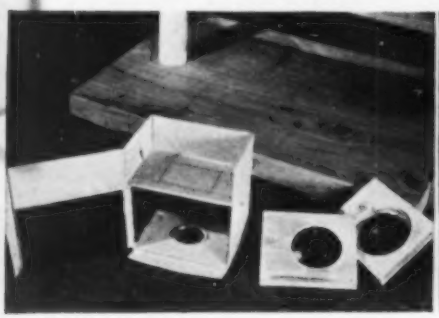
The principle is simple. A vertically sliding camera holder contains a supplementary lens, while a cardboard dummy camera has a lens of the same focal length as the camera lens. The dummy camera, which has ground glass instead of film, is used while adjusting the camera holder to sharp focus, after which the real camera is put in position and the picture snapped.

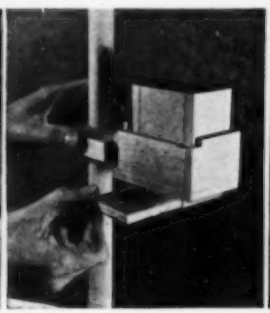
Design the camera holder so that the camera will always assume the same position when laid on it. The supplementary lens may be a regular copying or portrait attachment, or one of the chipped-edge lenses now available at low cost.

Make the dummy camera out of cardboard, proportioned so that its lens, when the dummy is in the camera holder, occupies precisely the position which the real camera lens would occupy. The lens in the dummy need not be of high optical quality, provided that its focal length approximates that of the camera lens. Mount a piece of ground glass in the dummy at the plane of sharp focus for objects more than 200′ distant. The camera field may be located on the ground glass in this manner: Put a piece of ground glass (rough side down) on the film aperture of your camera, focus at infinity, and then put the camera in the stand. Adjust the height until a sheet of newspaper tacked to the easel is in sharp focus and note the area covered. Then put the dummy in place of the camera and mark the same field on the ground glass.

To take a picture, focus with the dummy camera and supplementary lens in the holder. Replace the dummy with the real camera, which should be focused for infinity and stopped down to f/16 or f/32, and make the exposure.—ERVIN WALTERS.

The cardboard dummy camera, below left, uses a lens with a focal length equal to that of the lens in the real camera. Note that the field limits are indicated on the ground glass. The other pictures below show how the supplementary lens and dummy are inserted in the holder. Different auxiliary lenses may be used





FOR CAMERA USERS

LETTER ALBUMS which combine space for six snapshots and two 4¾" by 8" writing surfaces are now on the market. Excellent for sending photos to service men, the folded letters protect pictures in transit, and may be used on receipt as pocket albums.

EXPERIMENTAL LENSES of different focal lengths and diameters may be bought in sets priced so that a single lens costs but a few cents. Though ground and polished, they are inexpensive because small chips on the edges make them commercially unacceptable. They may be used as supplementary lenses for close-up or telephoto work and for making ground-glass or enlarging focus magnifiers, color-film viewers, and telescopes. Instructions come with the sets.

PORTABLE DARKROOM equipment, compactly arranged in an easily carried case, is now being made for the armed forces. Similar models are planned for postwar civilian use. Besides chemicals, paper, trays, and a daylight developing tank, the case holds a timer, safelight, thermometer, easel, and an enlarger that can be powered by a car battery. It also has space for a camera, flash synchronizer, and filters.

HOT-WEATHER DEVELOPMENT of films is said to be easier and safer with certain new chemical solutions. Films can be processed in temperatures that range up to 100 deg. F. without risk of softened emulsion or reticulation. The temperature-resistant solutions include developers, hardeners, and fixers. Photographers working in hot weather in temperate zones, those in the tropics, or those using makeshift field darkrooms will find the chemicals of special value.

Ripping a cabinet-rail tenon. The length is gauged by a stop block clamped near the end of a straight fence that is long enough to hold the work steady

Special Jigs and Attachments ADAPT

Your Bandsaw

TO MANY USES

By EDWIN M. LOVE

HOMEMADE attachments and jigs will greatly extend the uses to which a small bandsaw can be put. They make possible accurate cutting of tenons, automatic sawing of irregular curves, thinning of stock for bending around forms, and other types of jobs.

What is a setup for cutting tenons? First cut the cheeks, or sides, of the tenons. To guide the work, clamp a piece of straight square stock to the table for a fence parallel to the line of sawing. This fence must be high enough to support the work accurately with the face side in a vertical plane. The distance from the fence to the saw blade is such that the kerf will be made in waste wood with its far side forming the tenon cheek. This distance should be established by making trial cuts in scrap wood. Clamp a block to the fence where it will stop the forward motion of the work when the cheek is cut to length.

With this setting, saw one cheek of all like tenons, sliding the face side against the fence. If the pieces have parallel edges, they may be turned end for end, with the face sides kept against the fence. The position of the stop block is shifted if the tenons differ in length.

If the pieces are equal in thickness, their opposite sides may be put against the fence when the other cheeks are sawed, but if the thickness of the stock varies, such reversal will make the tenons either too thick or too thin. In this case, the fence should be reset to keep the face sides of the pieces against it. Shifting of the fence can be avoided if it is first set to cut the cheek opposite the face side. Then a shim of proper thickness may be inserted between the fence and work for sawing the face cheeks.

To cut the shoulders, as shown in one photo and in the sketch, clamp a stop block to the table at right angles to the blade. Also clamp on a length block to locate the tenon ends. Rest the piece to be cut on edge, rock the upper edge toward the stop block, and slide the lower edge forward until the blade severs the waste. As

before, use test cuts when setting the blocks, and make allowances for variations in stock thicknesses.

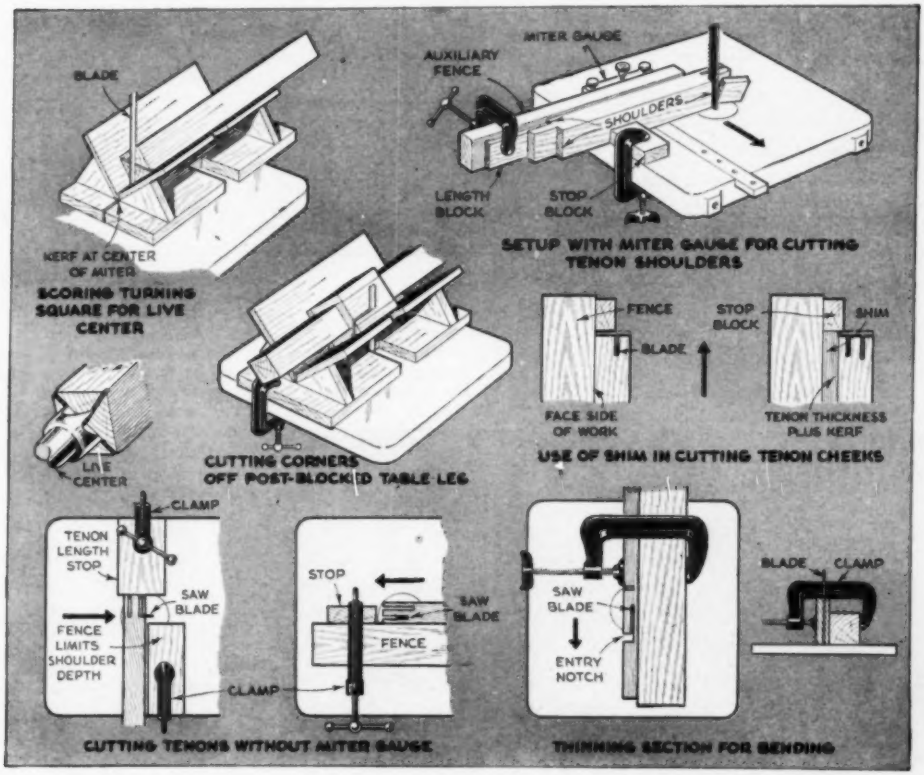
These methods apply only to comparatively short stock cut to exact length. Trim the tenons to width with similar setups, but with the face sides lying on the table. Trim the shoulders freehand or use the miter gauge.

When through tenons are made, cut the pieces roughly to length and use shoulder stops to locate the shoulder cuts for the second tenons after the first ends are cut. This assures accurate shoulder-to-shoulder measurements and correct frame dimensions after assembly. It is a good method to use even when the stock is precut to length. If the bandsaw is equipped with a metal fence, screw a larger auxiliary fence to it so as to give a firm support when wide work is handled.

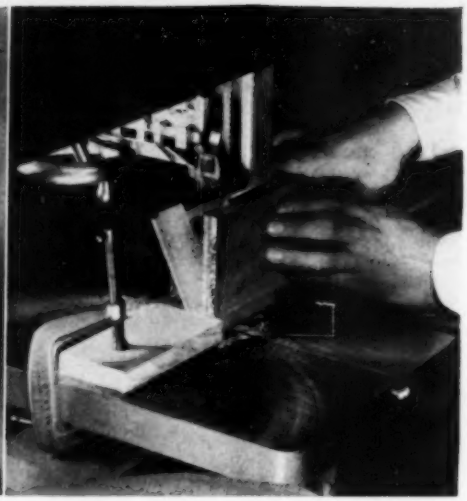
Of what use is a trough jig? This is a jig in which a piece of square stock can be supported cornerwise with the diagonals vertical and horizontal. The construction is shown in the drawing. Make a center kerf at one end and notch one side. A typical use of this jig is in scoring the ends of a turning square to give bite for the live center of the lathe. Clamp the jig to the table with the blade in the end kerf and feed the turning square against the saw, cutting about 1/16" deep. Turn up the other diagonal and repeat.

With the same jig clamped to the table so that the blade enters the wider side notch, it is possible to trim off the corners of built-up table legs. This saves turning time in roughing down the bulbs on post-blocked turnings and the like.

How is part of a rail sawed thin? Clamp the work to a heavy squared piece. Notch the inner face where the bend is to begin and make a kerf at the end. The slot can be made with several bandsaw cuts and a sideward motion to break out the waste. The blade is then entered to rip out the required portion. Cut the thin section an extra ½" long to allow wedges to be driven in for tightening. This method of clamping the piece to a heavy squared piece of stock is useful on many jobs since it gives ade-



A rail being thinned to allow bending is clamped to a 3" by 4" piece permitting freehand guiding

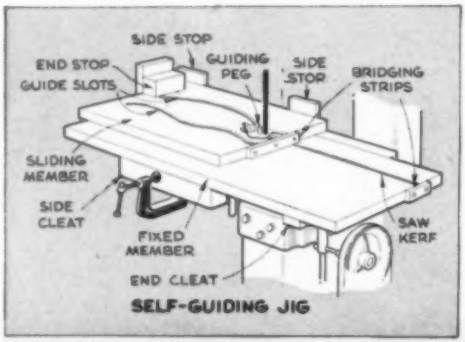


Accurate shoulder cutting is assured with stop and length blocks to control the depths of tenon cuts

quate support when freehand cutting is done.

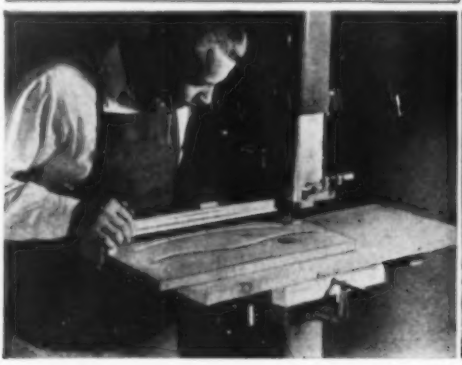
What can be done to correct saw-blade lead? If the blade doesn't lead true, it can often be improved by holding an oilstone lightly against the side to which it leads while the saw is running, thus reducing slightly the set of the teeth on that side. A little lead is of no consequence in freehand work, and the fence can be quickly adjusted for ripping to make it parallel to the line of cut, but when a miter gauge is used, difficulties due to wedging may be encountered. Sometimes this can be corrected by loosening the table mounting screws sufficiently to allow the table to be swiveled by light mallet taps on one corner.

How are self-guiding jigs made? The drawings illustrate a basic type. The size depends upon the design to be cut. The lower, or fixed member, has cleats beneath it to locate it on the saw table, and it has a saw kerf to allow entry of the blade. Set a guiding peg in the fixed member in front of the blade, and if the curve to be cut allows, add another peg behind the blade. The



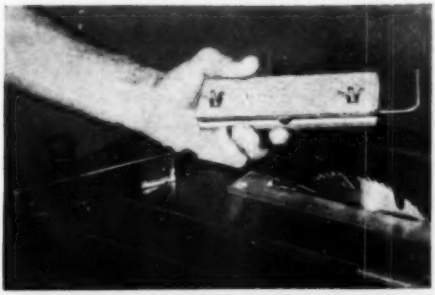
SELF-GUIDING JIG

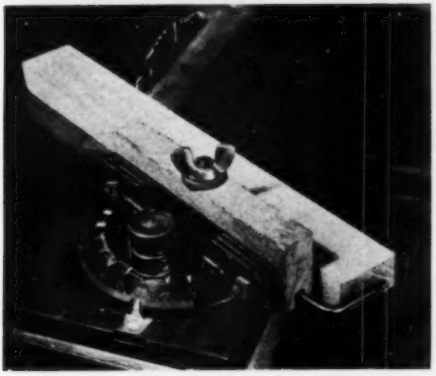
At the left is a sketch of a jig for sawing several layers of plywood at one time. Before cutting, make sure all pieces are up against the stops. A sliding pin guides the work as it is sawed, thus eliminating layout and producing accurate work at the same time



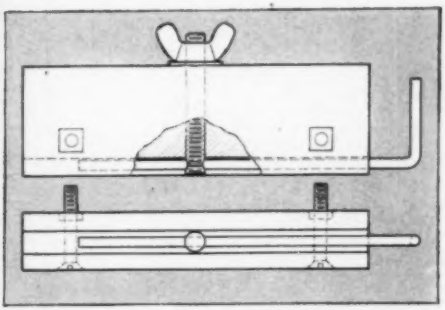
upper member of the jig is a sliding form with one or more guide slots cut in it. These must be accurately made, with no more than free sliding clearance on the pegs, and they must be long enough for the blade to run free in front of and behind the parts to be cut. Screw on stop blocks, as detailed, and also hardwood bridging strips to stiffen the slit ends of the jig members. Place the stock to be cut against the back and side stops of the sliding member and push forward until stopped by the peg.

Stop Rod Prevents Creeping of Miter Cuts on Circular Saw

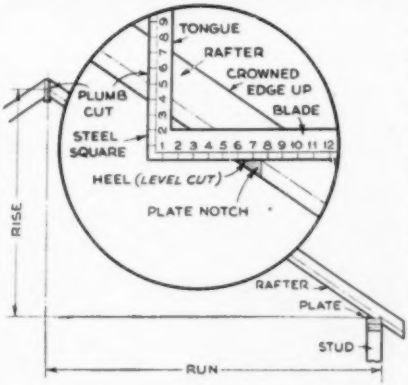




MAKE a ¾" hardwood block as long and as high as the face of the miter protractor. Set two countersunk bolts in one side of the block, with nuts set flush on the other side. Let the bolts extend ¾" to go through holes in the miter gauge, where they are attached with two extra nuts. Cut a groove in the bottom of the block for the stop rod. A vertical hole takes a bolt having a hole drilled through its lower end to let the rod slip through. When the wing nut on the upper end of the bolt is tightened, the sliding rod, with a right-angle bend at the end, is locked and holds the work from creeping. If you make rods of various lengths, you can handle many sizes of work.—B. B.



BRACES AND COMMON RAFTERS [SHIPSHAPE HOME]



The plumb and level cuts of a common rafter are determined by the rise and run of the roof pitch. The rise is the vertical distance between the plate and a point on the plumb cut which is located by extending a line along the rafter, parallel to its edge, at the depth of the plate notch. The run is the distance from the center to the outside of the plate. This is usually expressed in terms of inches rise per 12" of run. The sketch illustrates 8" in 12".

Lay the square on the stock with the figures coinciding with the crowned edge. A line drawn along the tongue is the guide for the plumb cut, and a line drawn along the blade is a guide for the level or heel cut.

The plate notch is usually cut 1" deep on the plumb for 2" by 4" stock. On wider rafters, cut deep enough to provide a 2" or greater bearing of the heel on the plate.

The same principle applies to cutting butted braces.

POPULAR SCIENCE MONTHLY SHOP DATA

Modern Cabinet Conceals

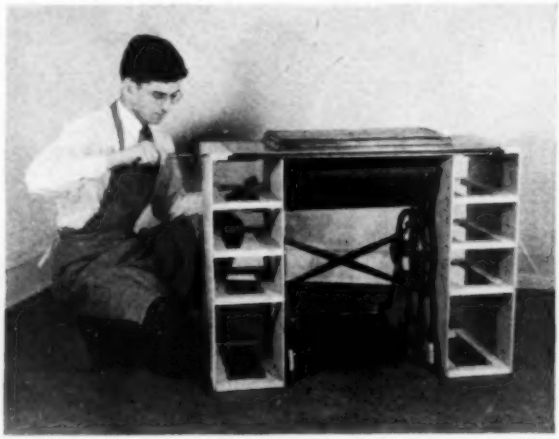
NEW DRESS PROMOTES IT

By Charles and Bertram Brownold

DUSTED off and rehabilitated, many old-fashioned sewing machines are doing yeoman work to help the family budget. With a new dress to hide ugly Victorian lines, yours may be brought out into the open where it will be easier to get at when there is mending to be done or new clothes to be made. The simple wooden cabinet shown can be made for any drop-head model

1 Wood extensions are attached at the sides and back of the machine top with the help of cleats

2 Use of a plumb line shows the back projects beyond the ironwork



3 Drawer cabinets of plywood attached to rectangular frames are screwed to the sidepieces and wooden parts of the machine

4 Corner blocks lock matching ones on a front panel, while others hold the cabinet to the frame

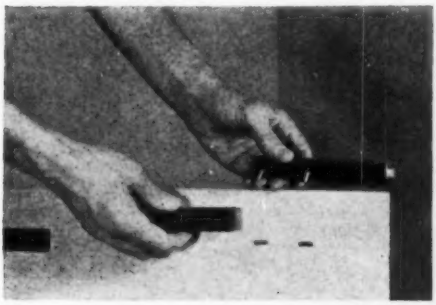
5 Sliding bolts made of hardwood dowels lock the top of this detachable panel to the cabinet

Old Sewing Machine

FROM ATTIC TO PARLOR

and will double as a living-room chest or desk, a dining-room sideboard, or a bedroom dressing table.

Discard the old drawers and attach a 2" by 3" piece to each end of the table, as in Fig. 1, rabbeting the inner edge to fit the routed edge of the top. Set the upper surfaces and ends flush and fasten on the underside with thin hardwood cleats, such as those shown in Figs. 1 and 2. The backs of the top drawers that will be installed later



6 These dowel bolts are screwed to the handles through slots in the panel that permit sliding

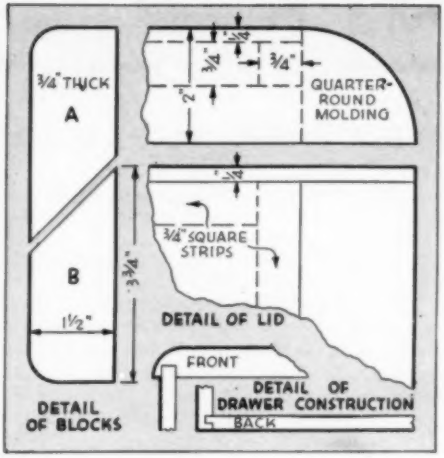
7 With its new dress completed, the old-fashioned machine becomes an attractive piece of furniture

Top and front panel removed and its dropped head lifted, the old machine does a good job of sewing

are cut down about ½" to allow them to slide past these cleats.

It may be necessary to attach similar extensions to the front and back if the metal frame projects beyond a plumb line held from the table edges (Fig. 2). On the machine used here, an extension was needed only at the back since all parts at the front were within the plumb line.

For each of the side drawer cabinets shown in Fig. 3, you need two ¼" plywood panels and four rectangular frames. These frames, of ¾" by 1½" stock, must be the same size and accurately squared. They have lap joints glued up under pressure The plywood panels are attached to them



Above, the machine serves as a dressing table when not used for sewing, and at right as a desk. Some details that will aid in construction are shown in drawings at the upper right

with countersunk screws driven in from the outside.

The inner panel of each cabinet is held tightly against the iron frame by fitted hardwood blocks at the bottom, as illustrated in Fig. 4, and at top it is fastened by screws to the woodwork of the machine. Openings should be cut in the plywood to accommodate any projecting parts of the ironwork. The outer panels are about 1" longer than the inner, and their upper ends are fastened with screws to the table-top extensions. One piece of plywood is fastened across the entire back of the machine.

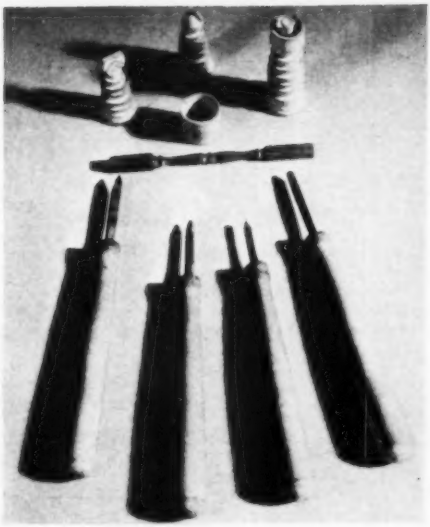
Stock 1" thick is used for the drawer fronts, the sides of which are rounded off as shown in the photographs. The deep bottom drawers—spacious enough to hold both materials and work—have fronts made of two pieces so that when closed each appears to be two drawers. All the fronts are deeper than the drawers themselves, covering the frames upon which the drawers slide, and are wide enough to be flush with the cabinet sides. The bottoms are plywood glued into rabbets ¼" from the lower edges of the fronts, sides, and backs. Drawer pulls 3" long are made of 1" hardwood dowels flattened on one side and fastened with screws from the inside.

When the machine is not in use, the top is covered by a lid having pegs that fit into holes bored in the table-top extensions. The lid is made of ¼" plywood and quarter-round molding held together by ¾" strips, as shown in a drawing, and on the front is a 1" plywood strip concealing that part of the sewing-machine top between the two drawer cabinets.

The treadle and driving wheel are kept from view by a plywood panel (Fig. 5) that is removable. Hardwood blocks near each lower corner of the panel and on the lower corners of the drawer cabinets hold this removable piece at the bottom (Fig. 4), while sliding hardwood bolts fasten it at the top. These bolts (Fig. 3) are made of 5" lengths of 1" hardwood dowels and are attached to handles on the outside with wood screws extending through slots. The bolts slide into holes bored in the drawer cabinet walls.

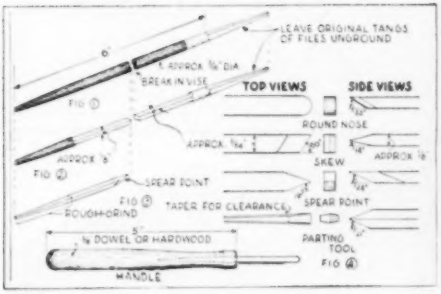
Either paint or stain may be used as a finish. Before painting, fill all exposed countersunk screws in the side panels with a hard-drying filler. If a stain is used, it will be necessary to glue a thin veneer panel over each side panel to cover the screw heads. The drawer fronts should be made wide enough to allow for this.

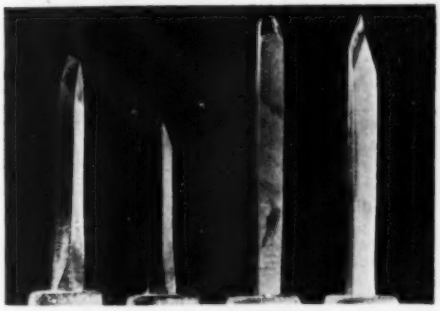
Model Maker's Turning Tools Are Ground from Small Files



FOUR excellent wood-turning tools, especially suited for model making and other small-scale lathe work, can be ground from two worn-out 6" round files. Break the files in a vise so that the pieces are of about equal length (Fig. 1) and grind them until they are rectangular in shape as shown in Fig. 2. The pointed ends need only be rough-ground (Fig. 3) since they will fit within the handles, but the exposed portions should have all file marks removed. Be sure that the surfaces which will bear on the lathe rest are ground smooth.

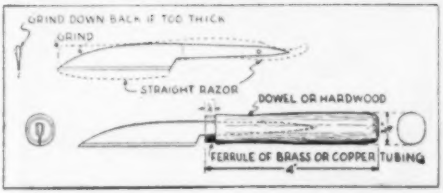
The cutting points should be shaped with particular care to secure the angles shown in Fig. 4; use a grinding jig if one is available. Handles can be made from ⅝" birch or maple dowel. Ferrules are not necessary if the handles are drilled out sufficiently before the tools are forced in. Finish the cutting edges on an oilstone to razor keenness. If you wish to make a set of larger tools, pillar files will need less grinding than larger round files.—C. W. BERTSCH.





Discarded Razor Transformed into Keen Whittling Knife

A WHITTLING knife that will hold an exceptionally keen edge can be made from an old straight razor. Since the original shaving edge is too thin for its new role, it should be ground back about ¼". Do not remove more than is necessary to thicken the edge slightly, because many razors are tempered only part way back from the edge. Take care not to "burn" the steel. Grind the entire blade to the shape shown in the drawing at the right, reducing the thickness at the back if desired. Use hardwood or a piece of ¾" birch dowel for the handle and attach a ferrule of seamless brass or copper tubing. If such tubing is unavailable, a discarded kitchen fork or spoon will probably yield a ferrule. Restore the knife edge to razor sharpness on an oilstone and make a leather or wooden sheath to fit the blade, as shown in the photograph.—C. W. B.

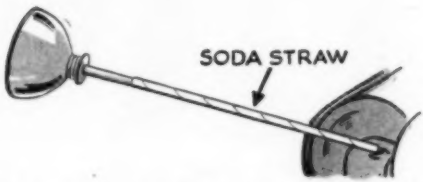


KEEPING THE HOME

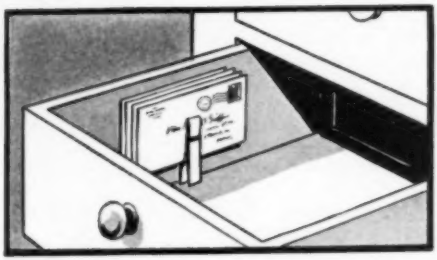
Most people prefer to have a furnace-regulating thermostat installed in a spot where it will not be noticeable and yet will serve efficiently. This often means that insufficient light will fall on the dial for accurate setting. Squinting in a dark corner and guesswork regulation of your heat can be avoided, however, by having a small notch filed in the dial face at the temperature or temperatures most frequently desired so that the exact setting can be made by touch alone. A small triangular notch like the one shown above can be made quickly with a three-cornered file

When loose ration points are received in change, a good precaution against their loss is to place them in an envelope pasted on the inside of the ration-book cover—a convenient, safe receptacle

Furniture casters won't stick to a floor and mar its sheen in very hot weather if a thin coating of floor wax is applied to the wheels. In damp weather a little wax put in the sockets of the casters will keep them rust-free and free-turning

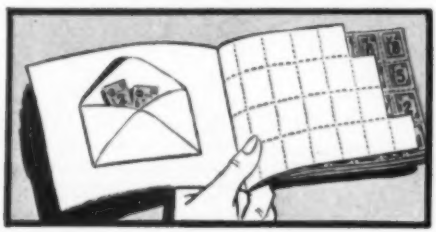


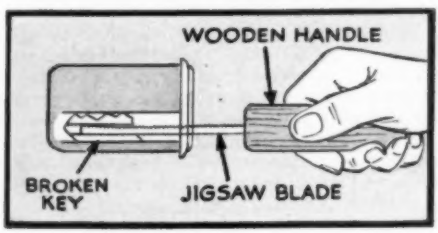
If you need to lubricate machine parts so placed that they are hard to reach, and an oil can with a long spout is not available, try using a soda straw on the end of the spout for an extension



Screw one leg of a spring-type clothespin to the inside of a drawer for keeping letters, bills, and receipts where they can be found when wanted

One way to get a broken key out of a lock is with a piece of jigsaw blade. Push the blade into the lock with the teeth pointing outward, twist it so they will be at right angles to the key, and pull

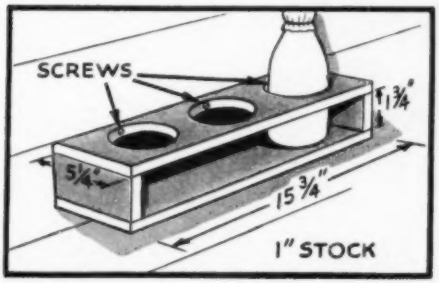




SHIPSHAPE

If members of your family or office staff absent-mindedly pocket a key that should be left for others to use, put the key on a ring that is too big to go into a pocket

In an emergency, a very satisfactory washer can be made for a faucet by removing the metal from the center of a round typewriter eraser. The hole will fit the screw, and the rubber can then be pared to proper size

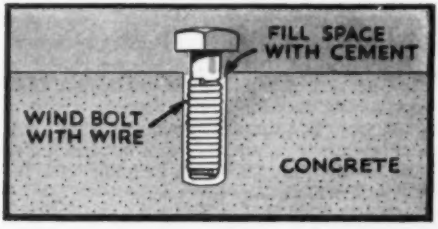


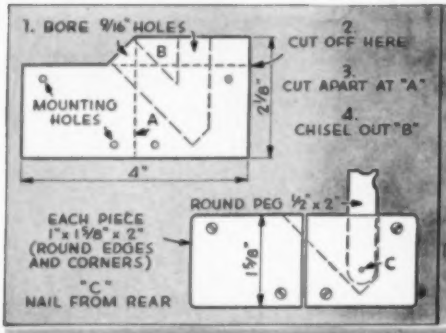
Milk bottles can't be kicked over and broken if they are held in this sturdy wall bracket. Make enough holes for your needs, and slant the back edges of the ends if your house is of clapboard

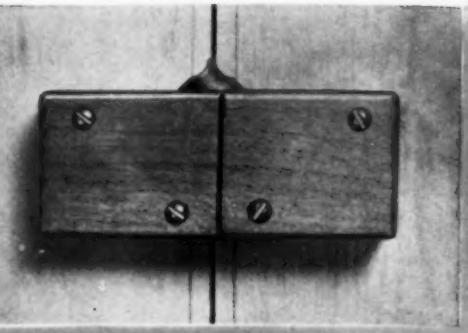
Friction tape is likely to dry out and lose most of its adhesiveness when removed from an original wrapper. Use an empty shoe-polish can as a handy, airtight container in which tape will keep fresh

Service-worn clothes wringers can be given many a day of extra life if the rust and discoloration that come in time from their iron roller cores are eliminated. These stains result from water that has seeped into the cores through the frayed and loosened rubber at the ends. A repair may be effected by removing the rollers from the wringer and fastening paper collars around the worn ends. The rollers can then be sealed against water and secured against rust if melted paraffin is poured into the collars. Gears and bearings should be cleaned with gasoline and coated with light grease

Bolts may be made to hold in concrete by winding the threads with wire, inserting them in drilled holes, and filling the space left with cement. They are withdrawn and reinserted with a wrench

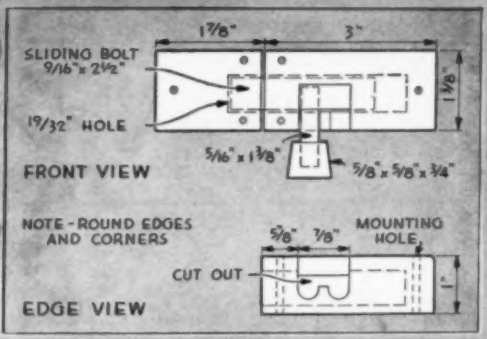






Made entirely of hardwood with the exception of screws, this drop-type latch is designed for use on a home-built cabinet or cupboard. Its pivoted moving part is cut out as shown in the drawing

The sliding bolt shown below, also of wood, is another distinctive latch. The bolt itself is a piece of hardwood dowel, while the remainder of the latch is made up from a block of grained stock. Care should be taken that the grain of the two halves match or form a pleasing contrast



Wooden Hardware Gives Cabinets

LATCHES AND HINGES MADE FROM NICELY GRAINED STOCK

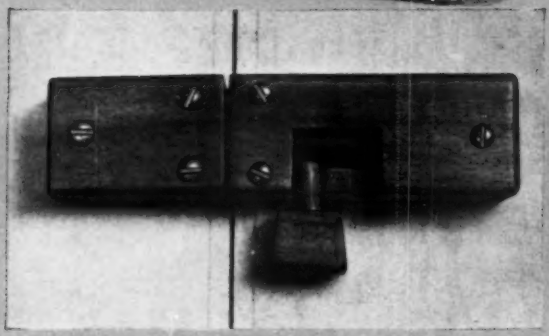
By FRANK WHEELOCK

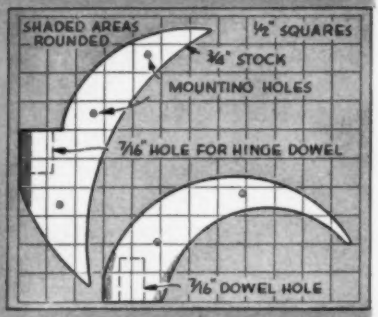
BEAUTIFUL latches and hinges that blend so closely with the grain of your home-built cabinets and cupboards that they seem to grow out of the wood can be made from small bits of matching hardwood. Others that will have as interesting an effect and add to the distinction of a piece may be turned out by the craftsman from contrasting woods. Many designs are possible, from the simplest lines to highly ornamental carvings, and any will be pleasing so long as the fittings are in keeping with the piece on which they are used.

Illustrated are two latches and two hinges for a cabinet door. The dimensions are suitable for many pieces, but the plans are intended primarily to give an idea of what can be done with hardwoods and to form a basis for designs of your own creation.

Care should be taken to have a pleasing flow of grain in adjoining parts, or else the grain of two pieces should be turned so that the contrast will be arresting. The two parts of each of the latches shown may be cut from the same piece of stock to obtain a flowing grain, or a small block can be sawed down the center with the grain for

With a length of dowel used as a pin, this wood hinge is strong enough for a cupboard





Another design for a hinge suitable for a door that has greater width than height

New Character

FOR HOME-BUILT PROJECTS

a perfect match. In the latter case, the inside faces are exposed, and the abutting ends are placed to let the grain coincide.

One of the latches illustrated is of the drop type with the moving part pivoted inside one of the halves. This part may be of dowel, shaped at the top as shown in the drawing. It is raised to unlatch the door and dropped into a slot in the corresponding half to hold it shut. The other latch has a sliding bolt cut from a hardwood dowel, while pieces of hardwood dowel also form the pins of the hinges.

Finishing will depend for the most part on the finish of the piece on which the fittings are used and also on the kind of hardwood from which they are made. In many instances, the finish desired will probably be one that will emphasize the wood grain. It should be put on in any case after a trial fit and before final assembly so that no unfinished corners will show in the exposed moving parts. Before the pieces are permanently assembled, all moving parts and contacting surfaces should be waxed and rubbed well. Parts of this kind that do not show, such as the hinge dowels, will need no finish except a thorough waxing. If it should be decided to use paint, don't paint parts between which there is friction.

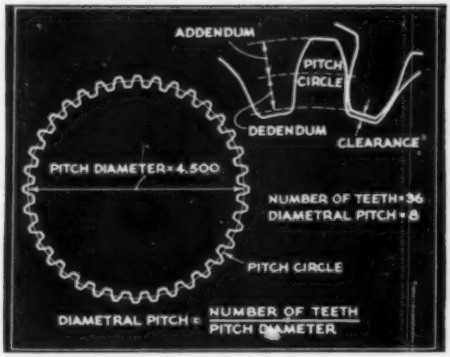
CUTTING GEARS on the MILLING MACHINE

ONE of the oldest and most common methods of cutting gears is on the milling machine, which is still extensively used despite the fact that other machines designed specifically for gear cutting can do the job faster. Gear hobbers, shapers, and planers, for instance, can be set up for mass production of various types of gears, such as spur, helical, bevel, spiral, and herringbone gears.

Before using any of these machines, the operator should have a knowledge of the fundamentals and nomenclature of gear-tooth design. Reference to a good handbook will enable him to set the machine to the correct speed and feed for the type of gear to be cut and for the kind of metal of which the gear blank is made. It will also allow him to check on the blueprint to be sure that none of the dimensions are contradictory. In addition, he should check the cutter to be used to make the gear with both the specifications given in the blueprint and the data in the handbook.

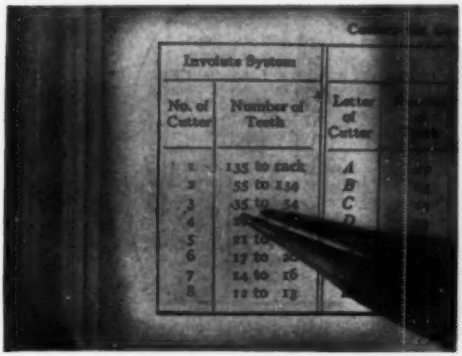
Actual setting up of the milling machine for gear cutting and its operation, along with important points in gear design, have been made the subject of one of the series of motion pictures used by the U. S. Office of Education for training machine-tool operators. Frames from this film, which is distributed for the Government by Castle Films, appear on the succeeding pages.

In setting up the milling machine, be sure to place the outer arbor support as close to the cutter as possible without danger of the gear blank striking the cutter. If the distance between this support and the machine column is too great, the cutter arbor will spring upward under pressure of the cut and result in teeth of uneven depth. For the same reason, a table jack is used to support the gear blank for the fairly heavy roughing cuts. Just how important it is to keep the cutter arbor and the gear-blank mandrel steady can easily be seen when one considers that the clearance of an 8-pitch gear of 36 teeth is only .0195".

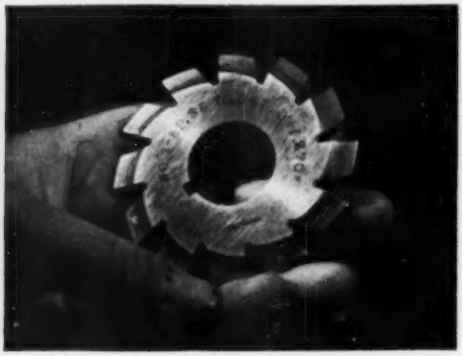


1 On gears, the pitch circle cuts the working center of the teeth, addendum and dedendum are equal, and clearance is added to give full depth of tooth. Diametral pitch is used in calculations

2 Here is the job. Cut 36 teeth in a gear blank machined to dimensions in the blueprint. The center hole is drilled and reamed so the face will run true when the gear is mounted on the mandrel

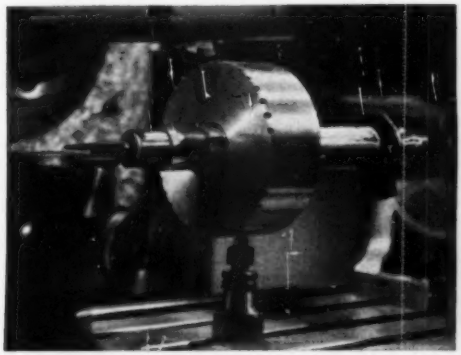


3 Since the shape of the teeth is to be involute, refer to the involute-system table of cutters in a handbook. A No. 3 cutter will provide this shape when the number of teeth is from 35 to 54

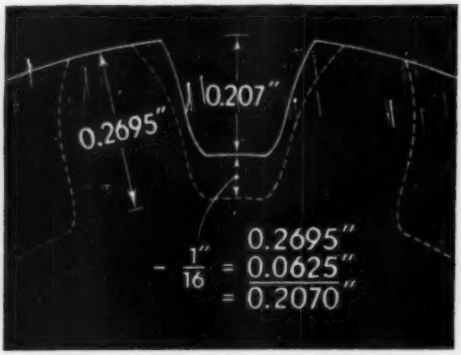


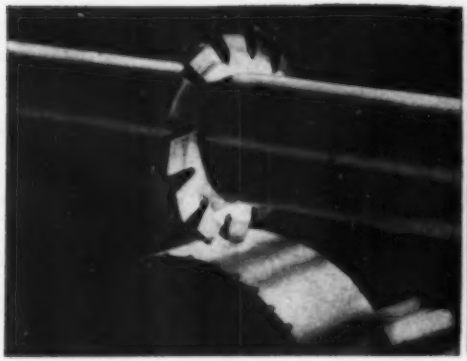
4 Specifications are stamped on the cutter. Here the diametral pitch (8), the number of teeth (35-54), and the full depth of tooth (D+f=.270") meet the requirements of the blueprint for the job

5 The blank below has been set up and notched for 36 teeth following a trial setting of the dividing head (see P.S.M., Oct., p. HW 481). A table jack keeps the mandrel steady during cutting

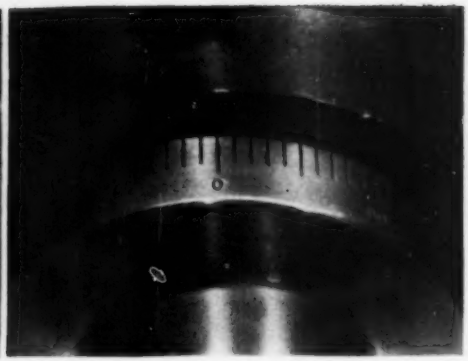


6 One roughing cut and a finishing cut of 1/16" will be sufficient for teeth of this size. To determine the depth of the roughing cut, subtract 1/16" from the full depth of tooth *(continued)*





7 As the first step in setting the machine for the depth of the roughing cut, the cutter is slowly rotated while the table is raised by hand until the cutter barely scrapes the gear blank



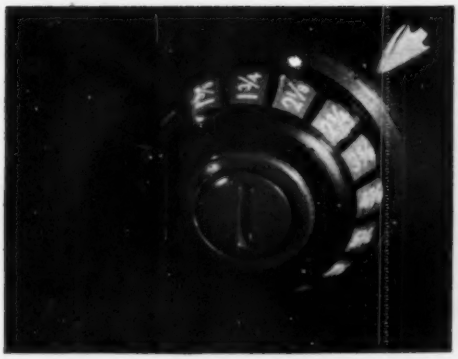
8 At this point, the index dial on the handwheel that moves the table vertically must be set at zero. Each division on the dial represents .001", and a complete revolution raises the table .100"

9 Run the table forward so the gear blank will clear the cutter; then raise it .207" for the roughing cut. This is accomplished by two full revolutions plus seven divisions on the index dial

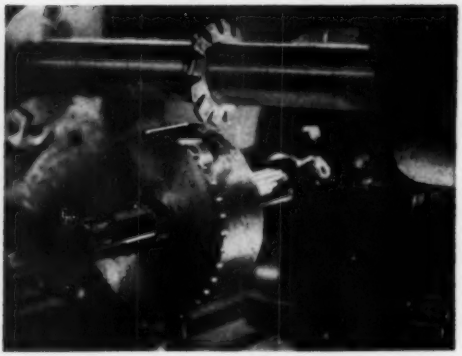
10 Cutter speed is next calculated. Since the gear is cold-rolled steel, a speed of 90' per minute is required at the cutter teeth. Dividing this by the cutter circumference gives 115 r.p.m.

11 On most milling machines, the cutter or arbor speed can be set by a speed selector. Below, the speed dial is set at 116 r.p.m., the nearest speed of this machine to that required for the job

12 Feed, the speed of the table movement, is now determined. The 12 teeth of the cutter will remove 12 chips .002" thick in one revolution, so the feed should be 116 r.p.m. multiplied by .024"

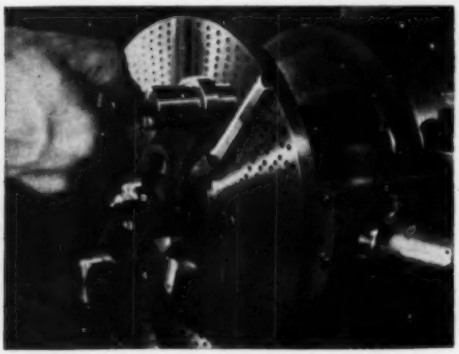


13 This gives a feed of approximately 2¾" per minute, at which point the feed-selector dial is set. It represents the distance in inches per minute the gear blank will be fed into the cutter



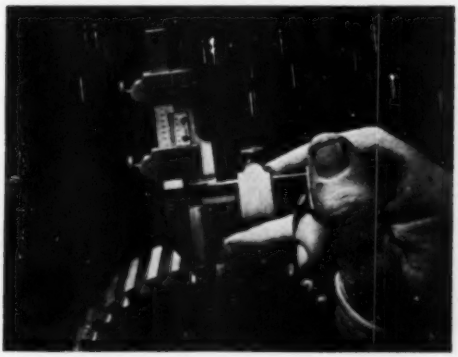
14 With the depth of cut, cutter speed, and feed set, take the first roughing cut, being sure to use an ample supply of cutting fluid; then stop the machine when the cutter just clears the blank

15 Set the table stop dogs to limit its travel at the point where the cutter clears the work. This keeps the cutter from traveling far enough to damage the dividing head and also speeds the job

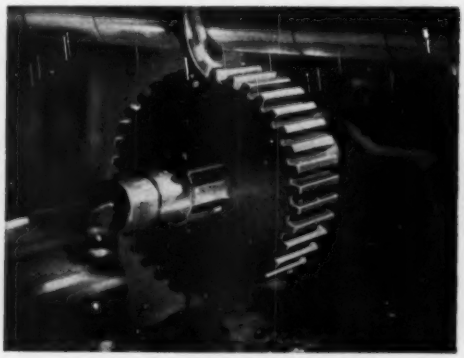


16 Stop the table at the end of each reverse stroke and index the blank for the next tooth according to the dividing-head setup. Due to backlash, indexing must be continuous in one direction

17 When all 36 teeth are rough-cut, raise the table 1/16" and make a finish cut; then index one space to finish the second face. Check width at the pitch line with gear-tooth vernier calipers

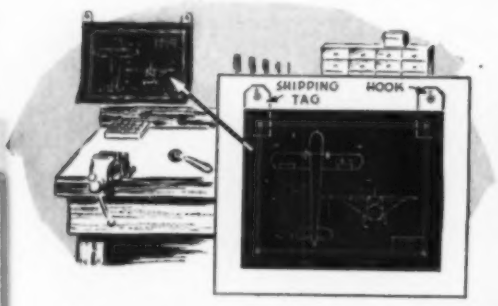


18 Cutting depth is adjusted, if necessary, to correct the pitch-line width. Indexing then proceeds forward for the rest of the gear. Cuts are light, and the table jack is no longer needed

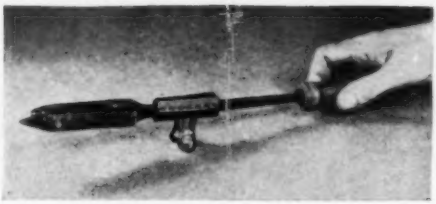


New SHOP IDEAS

BLUEPRINTS remain cleaner and last longer if they are kept off workbenches and left uncreased. One foreman lengthens the life of shop drawings by stapling two shipping tags behind the top edge of each as shown below. The blueprints can then be hung on two screw hooks over the workbench or machine where they are needed. A large number can be stored on two long curtain-rod hooks. If staples are not available, the tags can be attached with glue.—RONALD EYRICH.



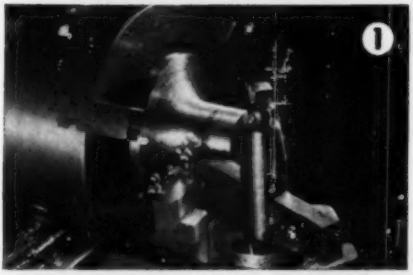
AIR PRESSURE speeds air power to smash the Axis. In the Fisher Body Division of General Motors, an ingenious trick suggested by Russell Dudley, an employee, has cut by 17 percent the time required to install electric wires in horizontal stabilizers. This was formerly done by first pushing through piano wire, which frequently caught at sharp bends in the conduit. Dudley's method is to tie the electric wire to a piece of string, blow the latter through with compressed air as shown below, and then pull the wire through.

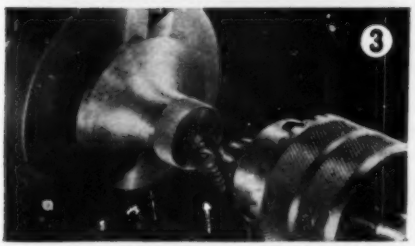


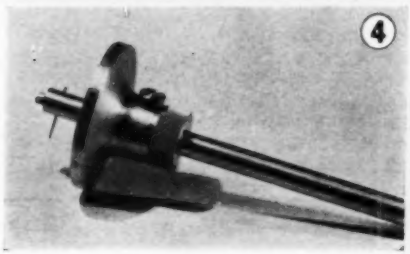
IN SOLDERING, a hot iron put down hastily or carelessly may char the bench or table top. If a spring-type paper clip is previously put on the tool just behind the head, such damage will be avoided. Spread the grips of the clamp slightly to afford a broader support.—W. SWALLOW.

Courtesy Grits and Grinds, a Norton Company publication.

WORN PIPE WRENCHES can be restored to service by regrinding the teeth on the jaws. This can be done by hand on any bench grinder equipped with a 100 or 120-grit, medium-grade wheel running at 5,000 surface feet per minute. The wheel face should have one sharp and one rounded corner, the sharp one to grind to the root of the teeth and the rounded one to provide clearance when teeth are being ground close to the shank of the jaw. It is usually the teeth on the movable jaw that require sharpening. The angle between teeth is generally 100 deg., and this should be preserved as closely as possible in regrinding. A dull wrench can usually be reconditioned in this way in a few minutes. Teeth can be resharpened several times if care is used, the depth of hardness and the amount of metal removed on each occasion being the only limitations on the life of a wrench so reconditioned. A simple file test will show whether the teeth are still hard; a triangular testing file should just bite enough not to slide over the teeth.







Shop Marking Gauge Has Replaceable Scriber

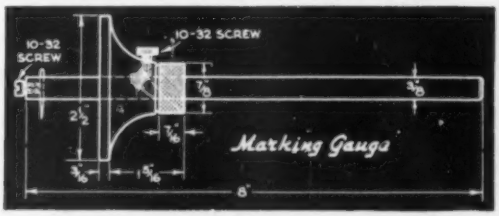
By C. W. WOODSON

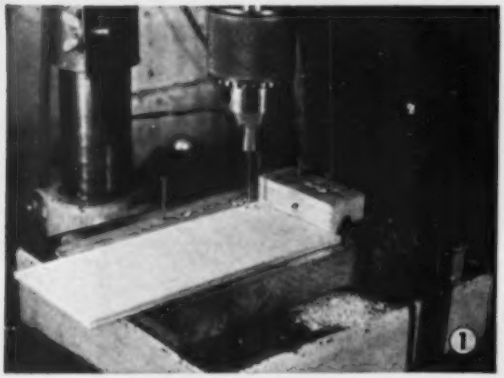
FITTED with a phonograph needle as a scriber, the gauge shown above will be found useful in making extremely accurate layouts on metal. Continued fineness of lines is assured since the needle can be changed when it becomes dull. The gauge is particularly suited to shops where aluminum sheet or steel plate is worked, but it will be a handy accessory also for many operations in home workshops.

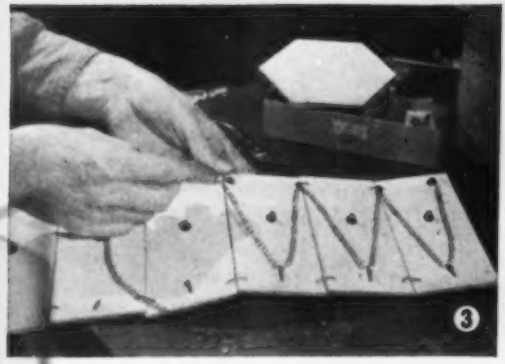
Chucked as in Fig. 1, a short piece of 2½" shafting was turned to make the base. A center hole was then drilled in the end for tailstock support, and the handgrip was knurled as shown in Fig. 2. During this operation, the tool should be kept flooded with oil, and the knurls should be sunk deeply enough into the work to make a perfect diamond pattern.

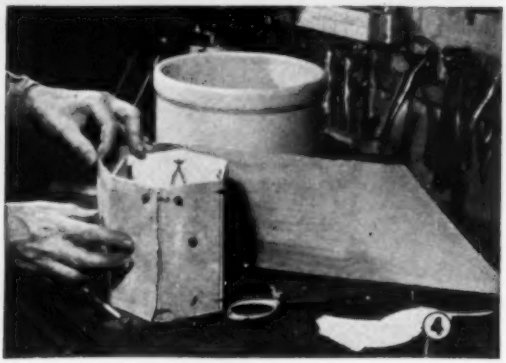
With the knurling complete, and the work still in the chuck, a hole was drilled through and reamed to the diameter of the spindle (Fig. 3). Then a hole for a thumbscrew was drilled and tapped 10-32 in the side of the gauge, and the thumbscrew was turned and threaded on the end of a ⅜" rod. The head was knurled, and the complete screw was finally cut off. An 8" length of drill rod forming the spindle was faced square at each end and drilled to receive the scribing point and a setscrew to hold it securely.

Detailed specifications for the metal-marking gauge









SMALL ELECTRIC

Resistance Furnace

HAS MANY SHOP USES

By Walter E. Burton

TEMPERING small tools, bluing metal parts, melting lead, and baking enameled pieces are just a few of the uses to which this efficient little furnace can be put in the small shop or laboratory.

A resistance coil of the kind used in electric heaters and toasters forms the heating element. Such an element can be purchased at an electrical supply house or salvaged from a discarded appliance. The furnace shown, designed to reach temperatures up to 1,000 deg. F., has one that draws 520 watts. Higher temperatures can be obtained by using a 1,000-watt element, or by making the heating chamber smaller.

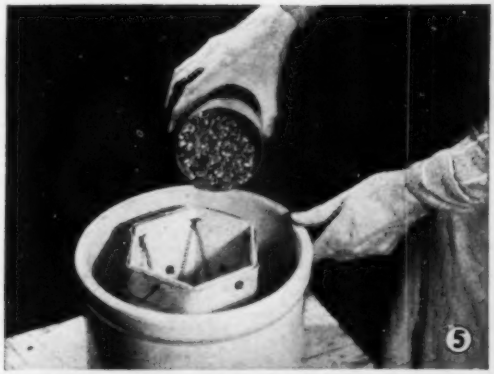
Two concrete-asbestos shingles ⅛" by 9½" by 24", either smooth or textured, are needed for the furnace chamber. With a hacksaw, on a jigsaw, or by scoring the material with an awl and breaking it over an edge, cut six rectangles measuring 1¾" by 6". Cut also a hexagonal bottom measuring 1¾" on each side.

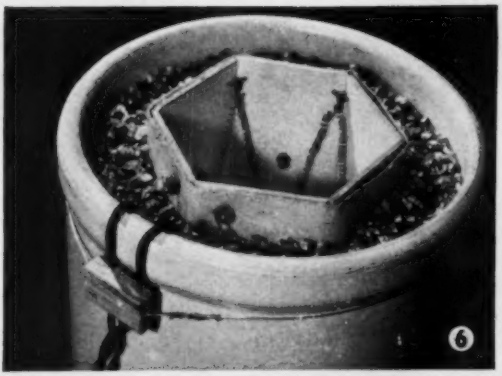
A jig such as that shown in Fig. 1 will speed the work of drilling a 1/16" hole ½" from the end and ¼" from the edge at each corner of these pieces. Center a similar hole ½" from one end of each to receive an S-shaped hook for holding the resistance wire. If you intend to use a crucible in the furnace, particularly a metal one, drill a hole in the center of each piece to take a 6-32 screw. Left long enough to project about ⅜" and secured with nuts, these screws will prevent the crucible from touching the element.

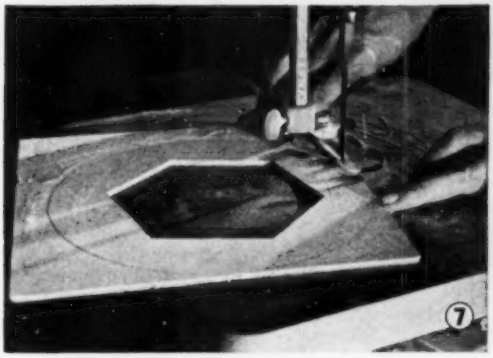
Link the rectangles together with small wire loops as shown in Fig. 2, with all the centered holes on the same side.

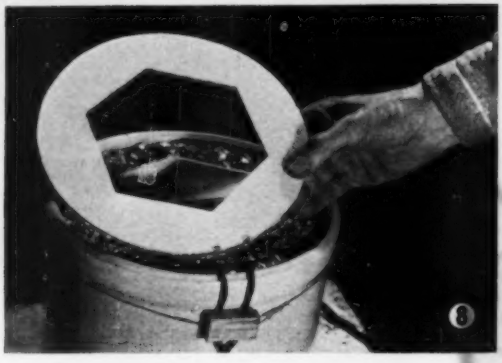
The coil hooks can be made of iron, copper, or nichrome wire. Insert the lower ones in the holes drilled for them and the upper ones through the links holding the pieces together. Drill a hole near the upper corner of each end rectangle to secure the two ends of the resistance wire. Measure the distance the wire will have to stretch, pull it out to slightly less than this length, and mount it as in Fig. 3.

With the element in position, fasten the two end rectangles together and insert the hexagonal bottom, securing this with some









black furnace cement. Wrap a strip of asbestos paper around the outside of the unit as shown in Fig. 4. Tie this with wire.

Expanded mica, rock wool, or similar fireproof insulation material is used to line the furnace body, which may be a 2-gal. crockery jar or a metal can or bucket 8½" in diameter and as deep. Pour enough of the insulating material over the bottom to bring the heating chamber even with the top of the housing as in Fig. 5; then pour more insulation around the sides, tamping it firmly.

The connecting wires should be of the asbestos-covered type, but may be bare for the last 2" inside the crock if well separated Secure them outside with a grooved wood or fiber block and a wire as shown in Fig. 6.

From the same asbestos shingle material, cut a disk to fit the crock with a hexagonal opening to accommodate the top of the heating chamber, as in Figs. 7 and 8. Add insulating material to within ⅛" of the top and fit this cover in place. A 7" disk of the same material fitted with a metal ring or knob serves as a lid for the furnace.

Work should rest on a platform of fire clay, firebrick, or metal about halfway between top and bottom. Some pieces may be suspended on wires from a rod laid across the top. For accurate temperature control a pyrometer should be used. The finished furnace ready for use is shown at the right.

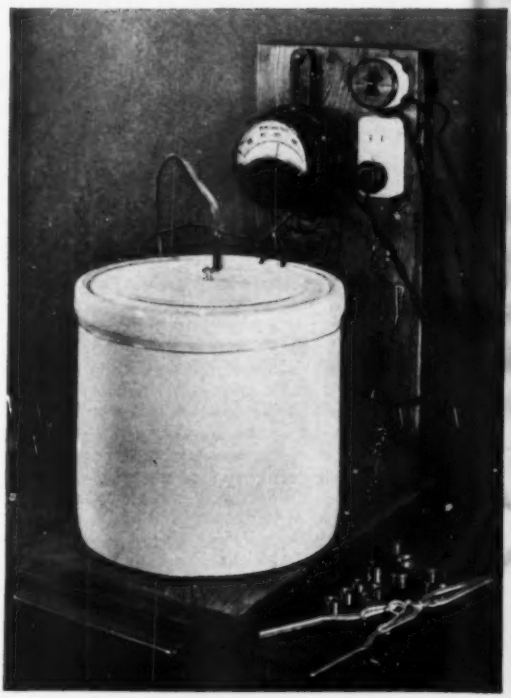


Photo courtesy of Westinghouse

How the Vacuum-Tube Grid

By JOHN W. CAMPBELL, JR.

USEFUL though the diode is in its various applications, it was not until Lee De Forest in 1907 inserted that simple third element—the grid—between the cathode and plate that the vacuum tube came into its heritage. That controlling grid has made it the indispensable tool not only of electronics, but also of physics, chemistry, medicine, metallurgy, and astronomy. It has rendered the electron the servant of industry instead of a plaything of the laboratory.

A diode passes current whenever the plate is positive with respect to its electron-emitting cathode. That plate-circuit current can be increased or decreased in just two ways: by controlling the emission of electrons (which in a thermionic-cathode tube can be done by varying the cathode temperature) or by altering the positive potential on the plate. Either method requires comparatively large current changes, such as we can bring about by the use of variable resistors, as in Fig. 1 in the drawings on page HW 558.

Suppose, however, that we inserted a miniature Venetian blind between the cathode and the plate, along with a microscopic motor that could open or close its slats. If the slats were closed, electrons from the cathode would be unable to reach the plate; no current would pass. With the blind open, only a few electrons would strike the slats; the majority would pass through, and a plate current would flow.

If we could build so tiny a Venetian blind, and a small enough motor to control it, we would be able to control a fairly powerful plate current by means of a small current—the current needed to energize the motor. But although mechanically possible, the method is complicated and impracticable. Instead, the triode tube makes use of an electrostatic equivalent of our Venetian blind—a grid. Its slats are not metal, but electric fields, and they can open and shut smoothly 10,000,000,000 times a second.

The grid is simply a lattice of fine wires

Electrical nerve centers of glass and metal speed the messages of modern warfare. These high-power transmitting tubes, destined for the U. S. Navy, will help to maintain ship-to-shore communication

between cathode and plate, or, in some tubes, an open helix of wire surrounding the cathode. If connected to the cathode and therefore at the same potential, a grid presents to electrons emanating from the cathode the same appearance of an open network as it does to the eye (Fig. 2 on page HW 558) and the full plate current passes.

Suppose, however, that the grid is made more negative than the cathode by applying to it an additional negative potential of, say, -1 volt. Nothing will appear changed to us, but electrons, "seeing" electrically, will behold something like the grid shown in Fig. 3. The wires have been electrically "inflated" to many times their original size, and the space between them through which electrons can pass has been diminished. The electrons on the grid constituting that charge of –1 volt will repel some electrons that would have passed before. Furthermore, a grid negative in respect to the cathode tends to block the strong positive attraction of the plate. Fewer electrons reach the plate, and the plate current is smaller.

If we increase the negative potential on the grid to –2 volts by crowding additional

trol another current powerful enough to fill an auditorium with sound through a loudspeaker, open doors, control heavy machinery, or do other useful work.

A potential as small as .001 volt is detectable in a standard amplifier. A vacuum tube such as the 6F5-G will react to a current of one one-hundred-billionth amp. In a special two-tube circuit, a current of less than one ten-billionth amp. controls a current of 1 amp., which in turn can control 1,000 amp. or more. Special tubes can detect a current consisting of only 30 electrons per second—a flow so infinitesimal as to be meaningless when expressed in amperes.

The reason such sensitivity is possible is that individual electrons fed onto the grid have a cumulative effect. As the grid cannot emit electrons, they cannot escape. Because the grid is already negative, electrons emitted by the cathode are repelled by it and cannot affect it. As the tube is evacuated, there are no gas ions to be attracted by the grid and discharge it. In a theoretically perfect tube, having a perfect vacuum and a fully insulated grid, a current of one electron per hour on the grid would eventually mount to a potential that would block the plate current completely.

But the triode has, in addition to its amazing sensitivity to minute electrical potentials, another important characteristic. It reacts

Controls Electrons

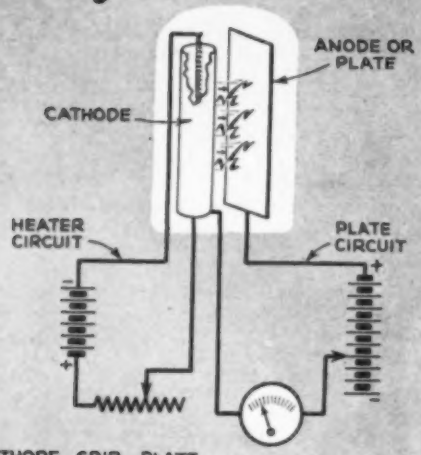
electrons on it, the wires will be inflated still more, as in Fig. 4, and even fewer electrons will reach the plate. Finally, if a sufficient negative potential is applied, the electrostatic fields around the grid wires will completely overlap as in Fig. 5—the "slats" of our electrostatic Venetian blind will be closed—and no current whatever will flow across the tube.

When grid wires are closely spaced, even a charge of a few volts will block the plate current completely. If they are widely spaced, a higher negative potential is necessary.

In the triode, or three-element tube, we thus have a method of controlling the plate current that the diode did not afford. The vastly important advantage of this grid control is that a mere charge—a potential, not a current—will affect the plate circuit. The triode is an ultrasensitive relay, in which an infinitesimal current can con-

The 8012, shown full size at right, is a transmitter tube that delivers 35 watts at 500,000,000 cycles. Below is a slightly larger 300-watt tube

Fig. 1



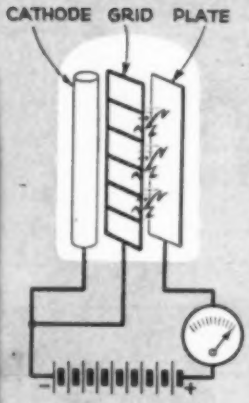


Fig. 2

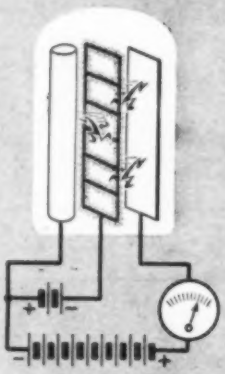


Fig. 3

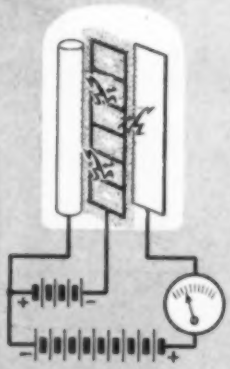


Fig. 4

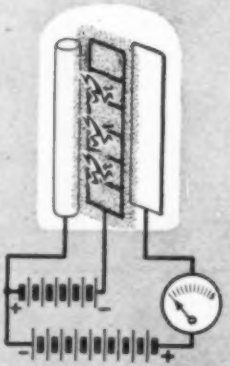
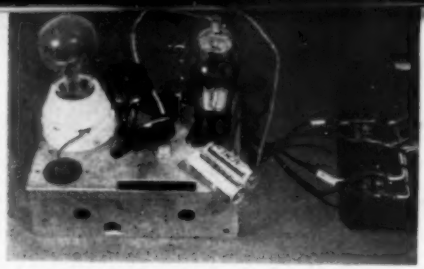
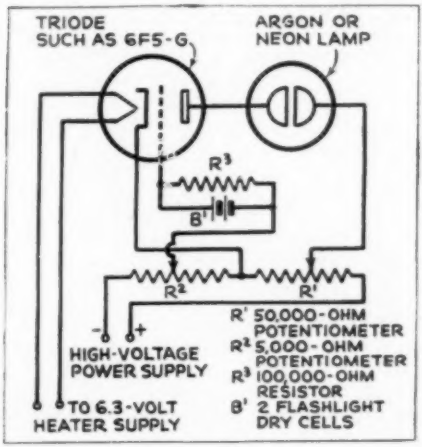


Fig. 5



This setup shows how grid changes affect the plate current. With a 275-volt power supply, 250 volts can be impressed on the plate and 25 on the grid. A few volts difference on the grid affects the lamp as much as a 100-volt change on the plate, the ratio indicating the amplification. Try varying the potentiometers and also reversing battery polarity. A glow spreads or diminishes on one plate of the neon lamp as the plate current increases or lessens



to changes in grid potential at almost the speed of light. Electrons have very little mass, hence very little inertia. They can be moved at tremendous velocities. Electrons can be impressed upon the grid of a vacuum-tube amplifier in a ten-billionth of a second and drained off as quickly. The plate current will respond to such changes in the grid potential faithfully, even though it may take more than a ten-billionth of a second for the electrons comprising that plate current to travel from the cathode to the plate. The plate-current variations would arrive a trifle later than the grid impulses, but all in correct order and properly spaced.

However, to charge and discharge a grid periodically, we must move electrons quickly and in great numbers. Small though their inertia is, pumping them into and out of a grid at high frequencies requires considerable power. The reason for this is that a grid constitutes one plate of a tiny condenser,

which in most small amplifier tubes has a capacity of only a few micromicrofarads. Now a certain number of electrons impressed upon a .001-mfd. condenser will produce a charge of, say, 10 volts. But the same number of electrons on a .01-mfd. condenser will charge it to only 1 volt. Therefore, the bigger the grid (that is, the greater its capacity) the more energy is required to pump electrons into and out of it.

A 1-mmfd. condenser will be charged to a potential of 1 volt by a current of 1 micromicroampere flowing for 1 second. To charge this same condenser to the same potential in a millionth of a second takes 1 microampere—a million times the current.

Radio amateurs working with short-wave equipment at frequencies up to 750 megacycles use very small "acorn" tubes in special circuits. At such frequencies, the capacitance even of a straight piece of hook-up wire becomes something to reckon with.

Triode Oscillator Generates Wide Range of Frequencies

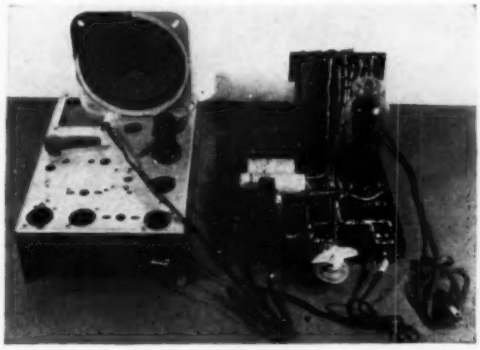
WITH the homemade oscillator shown below, you can generate audio frequencies ranging from the lowest to the highest audible to the human ear. The addition of a telegraph key makes the oscillator a useful code-practice set.

By impressing upon the grid of a triode the oscillating current of a resonant circuit, we obtain in the plate circuit a current of the same frequency. Since this same plate current flows in the cathode circuit, which includes the lower half of the inductance L, the varying magnetic field there created will induce a like oscillating current in the remainder of the inductance, thus maintaining the energy in the resonant grid circuit. With the proper values of capacity, inductance, and resistance, any desired frequency can be generated. When the resistance R is adjusted to zero, the circuit oscillates at a frequency given by the formula

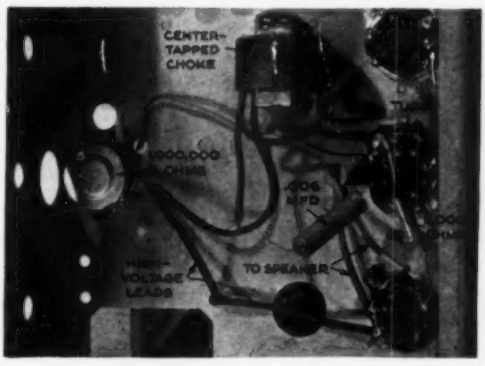
$$F = \frac{160}{\sqrt{LC}}$$

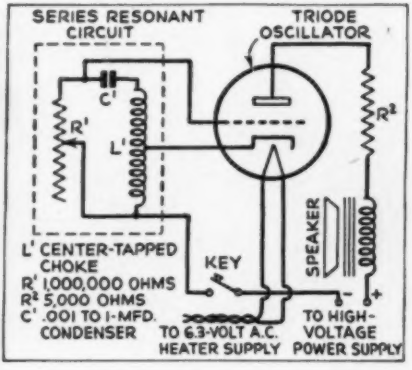
where F is the frequency, L the inductance in microhenries, and C the capacitance in microfarads.

With a center-tapped filter choke and a .001 to 1-mfd. condenser, a 1,000,000-ohm potentiometer tunes the circuit to various frequencies. If you have no center-tapped choke, you can use an audio transformer by joining a primary and a secondary lead so that current flows through both in the same direction. The juncture acts as a center tap, and the speaker-lead resistor can be omitted.



Mounted on an old radio chassis, the oscillator is powered by a high-voltage supply shown at the right of it. Below, the underside of the chassis

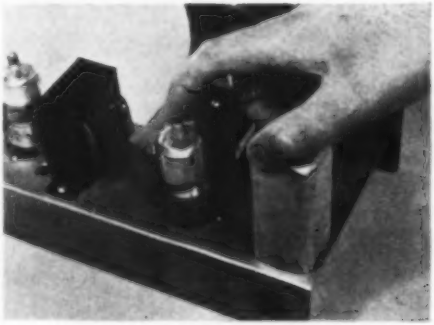




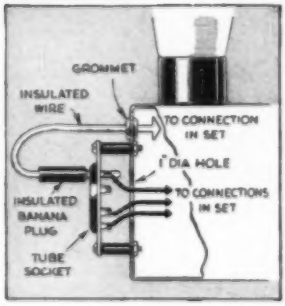
Servicing Your Radio

NOISY VOLUME CONTROLS of either the wire-wound or carbon type often can be repaired simply by removing them from the chassis and cleaning them thoroughly. Soak a piece of clean linen in ordinary noninflammable cleaning fluid and rub the windings and contact arm of a wire-wound control until they are clean. A little more care is necessary with a carbon control. Roll a small piece of absorbent cotton tightly around the end of a toothpick, dip it in the cleaning fluid, and wipe carefully, with a little pressure, along the carbon strip. Be sure also to clean the contact springs on the rotating arm.

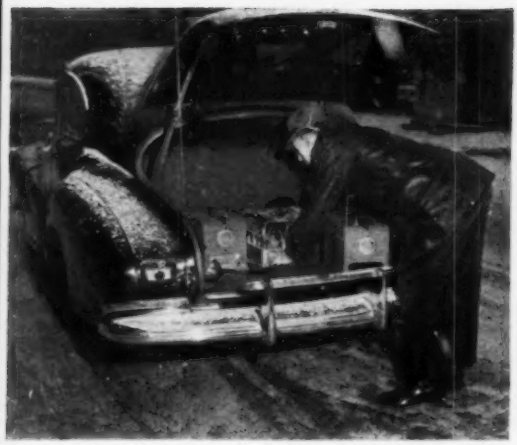
SLIPPING IN THE TURNTABLE of a phonograph may cause difficulties that are sometimes incorrectly attributed to the motor. Look first at the rubber washer between the turntable and the motor spindle—the cone-shaped piece marked with an arrow in the photograph at left—for it may be to blame for the turntable failure. Frequently this washer becomes soaked with oil from the motor, and when this is the case, the washer surface is made so slippery that it cannot establish a firm contact with the turntable. Cleaning is rarely effective, and it is much more satisfactory to replace the old washer with a new one.



YOUR HANDS USED ALONE sometimes will serve to locate trouble in a balky receiver. For instance, if reception is weak, touching the grid cap of the converter tube —a tube such as the 6A8 or 2A7—with one finger and chassis with another, as indicated in the photograph, may make it come in louder. This will mean that the secondary of the antenna coil is open or that a corroded connection on the coil is causing an extremely high resistance in the circuit. Even persons shy of electricity need have no fear in making this test, for no shock will be experienced if directions are followed. Don't touch parts below the chassis.



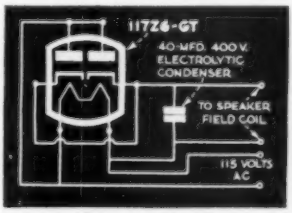
WAVEBAND SWITCHES and other switches in a receiver circuit may be replaced when they break down by using a four to six-prong tube socket and an insulated banana plug, as shown in the photograph at the far left. The socket may be mounted on the back of the chassis, following the directions detailed in the drawing. Two sleeves placed under it will raise it slightly from the chassis so that there will be room for insertion of the plug.

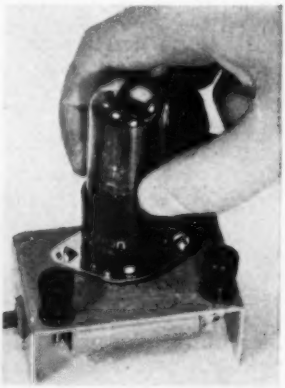


radio ideas

FM POLICE RADIO EQUIPMENT now incorporates "iron-core" or inductive tuning among other new features. The closely controlled movement of an iron core in and out of a small form-wound coil permits easier and more accurate tuning, and reduces the effects of car vibration on tuning adjustments. Likewise new is a "workbench" support which proves convenient when the chassis is inverted for inspection or repair. Test jacks permit direct, simultaneous readings of several functions at one time. All tube sockets and tuning controls are stenciled on the top of the chassis.

A MIDGET RECTIFIER for energizing any electrodynamic speaker having a high-resistance field coil can be made as shown in the accompanying diagram. This will permit substitution of such a speaker in a circuit originally calling for a permanent-magnet speaker. One of the advantages of the midget rectifier is that it is small enough to fit any radio chassis and therefore can be used in a wide range of circuits in which such a speaker is to be supplanted. It will provide the current necessary to operate an electrodynamic speaker if it is equipped with a rectifier tube capable of carrying at least 150 milliamperes, and is a handy expedient when a permanent-magnet speaker is not available.





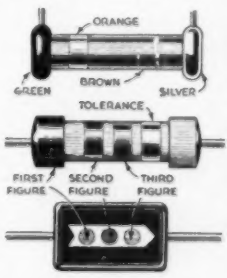
RESISTOR AND CONDENSER CODES

[ELECTRICAL]

Small carbon resistors and small mica condensers required in a modern radio set are too small for convenient labeling with numerals, so the Radio Manufacturers Association has adopted a standard code-marking system, a color code. Digits are represented by colors as follows:

0	Black	5	Green
1	Brown	6	Blue
2	Red	7	Violet
3	Orange	8	Gray
4	Yellow	9	White

Two types of markings are used on resistors. The straight-end, tubular-type resistor, with leads coming straight out of the end, is marked with color bands. The band at one end represents the first digit, the next band gives the second digit, and the third band gives the number of zeros. That is, if the bands are brown-green-orange, they are read 1-5-three zeros, or 15,000 ohms. This straight-end type sometimes carries a fourth band, either gold or silver. This band indicates the accuracy of value, gold being the highest.



The second type of resistor—with leads coming out at right angles—uses the body color for the first digit, tip color for the second, and a dot or band at the center for the number of zeros. Thus brown body, green tip, orange band should be interpreted as 1-5-000 or 15,000 ohms.

Condensers use the same type of color coding, but the readings are in micromicrofarads, and the color is applied in small dots with an arrow indicating the order in which they are to be read.

POPULAR SCIENCE MONTHLY SHOP DATA

Dissolved Oxygen Reduces Power Needs and Increases Life of Electron Tubes

THE recent solution of a long-standing electronic mystery promises new radio tubes which will have both longer operating lives and reduced power requirements. Similar improvements are foreseen for other electron tubes.

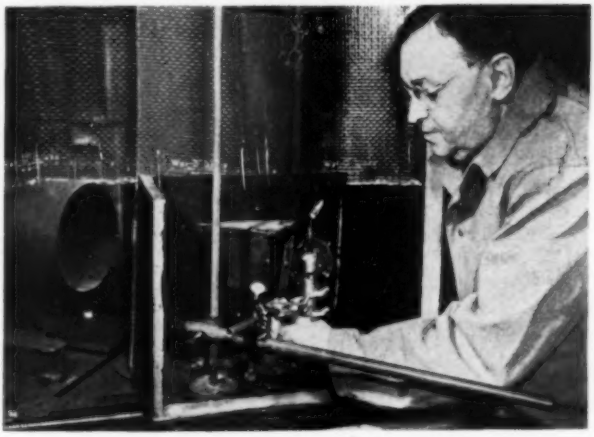
It is the purpose of a vacuum-tube cathode, of course, to discharge a volley of electrons to the plate. For 40 years scientists have known that an oxide-coated cathode emits electrons more readily than a pure metal one, but they haven't known why. Now Dr. Harvey C. Rentschler, Westinghouse research expert, has an answer.

Atoms of oxygen, he finds, apparently distort the crystal-lattice structure of the cathode and thus enable the electrons to be shot off more easily. Moreover, a method has been discovered by which oxygen can be dissolved within the metal of the cathode, much as salt can be dissolved in water. In previous practice, certain types of cathodes have been made by forming oxides of various metals into a paste and baking the paste on tungsten supports. The procedure developed by Dr. Rentschler consists of heating cathodes of zirconium, titanium, thorium, or caesium in oxygen until a "solid solution" of oxygen is uniformly distributed throughout the metal.

High-voltage vacuum tubes offer a special application of this new technique. Hitherto the cathode of a high-voltage tube has had to be made without an oxide coating because the strong electric field would rip the coating from its support. Oxygen dissolved in the cathode, however, is an integral part of it and can't be pulled off.

Within the glass tube is a strip of zirconium which Dr. Rentschler is treating with oxygen to improve its electron-emitting characteristics

Below, a photoelectric cell having one of the new cathodes is tested by a spectroscope. Electron emission is caused by both light and heat



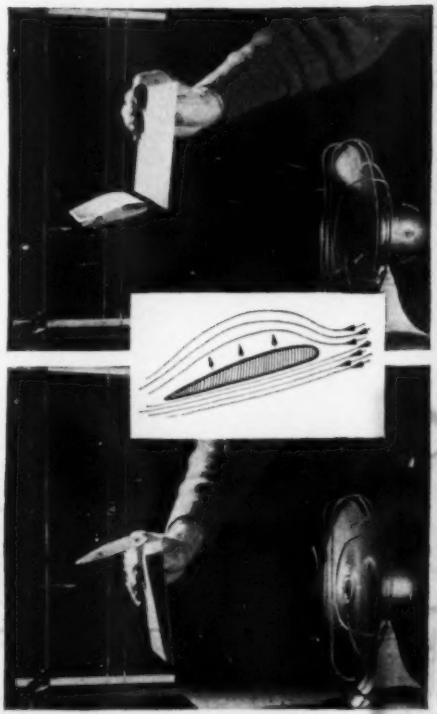
How Airplane Wings Get Their Lift

WHAT gives an airplane its lift? Near the beginning of the eighteenth century, a Swiss mathematician, Daniel Bernoulli, discovered a physical principle which accounts for the greater part of the answer. In the course of experimenting with fluids, both liquids and gases, he found that pressure decreases as velocity increases.

The Bernoulli principle explains the increased draft of a chimney when wind blows across its top, the bursting of a house near the path of a tornado, the curve of a ball that is spun as it is thrown. It is also one of the most vital factors in aerodynamics, ac-

home EXPERIMENTS

AN AIR STREAM directed in the space between two freely suspended oranges will result in lowered air pressure in this area. The outside air pressure will thereupon force the two oranges together. Suspend the oranges so that they are about 1½" apart when hanging at rest.



MAKE THIS AIRFOIL by covering a cardboard-and-dowel frame with paper. Holes are needed in the paper to enable the airfoil to move freely along the guide wires as pictured in the photographs above. Stops on the wires cause the airfoil to rest normally just a little below the center of the slip stream from the fan. To show that the airfoil gets more lift from the partial vacuum above the wing than from the air stream under it, hold a strip of cardboard under the leading edge so that only the under surface is exposed to the breeze of the fan. The airfoil will rise a little. Then make a second test by holding the cardboard in such a way that the fan blows only above the airfoil, which now rises much higher.

counting for nearly 75 percent of the total lift exerted by an airplane wing. Air passing rapidly over the curved upper surface of a wing reduces pressure there, causing a partial vacuum. The relatively greater pressure beneath the wing then buoys it up. This may sound mysterious, for the idea that lift comes from a partial vacuum above a wing is not the most obvious explanation. But by performing the accompanying simple experiments, you can prove to yourself how the Bernoulli principle plays a part in modern aerodynamics.

A MANOMETER, a device used for measuring gas pressure, can be made by partly filling a bent glass tube with colored water. The level in both sides is normally the same, but when you blow through another tube squarely across one open end of the manometer, the water rises in that leg, showing that the air pressure on that side is reduced. As you blow harder, increasing the speed of the air flow, the water rises higher. Similar manometers are used in determining pressures on the various parts of airplane wing surfaces and on the wings of test models. Atomizers work on the same principle.

CUT TWO DISKS of cardboard about 4″ in diameter. Make a small hole in the center of one and seal the end of a drinking straw over the hole with sealing wax. Push a pin through the center of the other disk. Hold the first disk about ⅛″ over the other with the pin sticking up into the straw. Blow hard through the straw, and the lower disk will jump up to the other. The harder you blow, the more firmly the disks stick together, since the air rushing between them reduces internal pressure while external pressure remains the same.

A TABLE-TENNIS BALL bounces up and down if supported on an air stream, but it won't fall to one side. As it tends to do so, the air stream creates a low-pressure area on the opposite side, and atmospheric pressure moves it back.

Magical Tricks
WORKED WITH CHEMISTRY
Simple Home Demonstrations To Mystify Your Friends

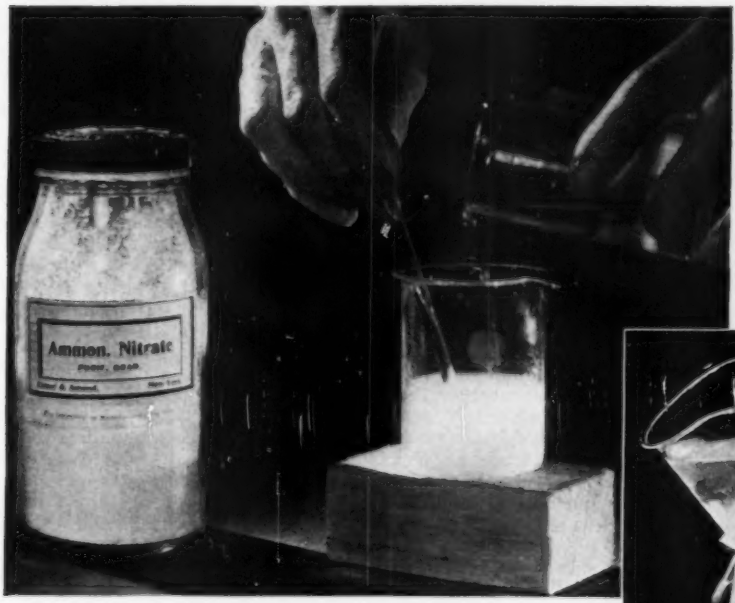
By KENNETH M. SWEZEY

ALTHOUGH it may be a far cry from the ancient alchemist's den to the modern laboratory, chemistry is still a science of amazement and seeming magic. Everyone who professes to be a chemist, amateur or otherwise, is expected by his lay friends to be able to conjure up wonders at the slightest notice.

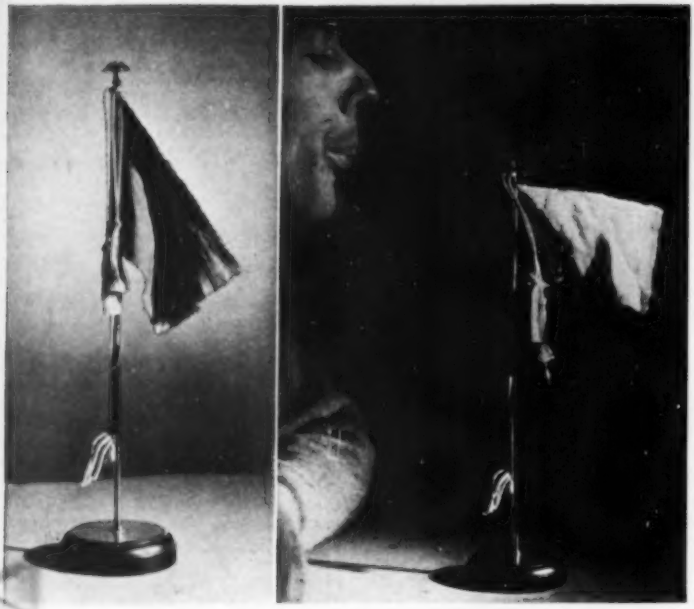
For personal pleasure, and to gratify these friends, every home chemist ought to develop a little "curiosity shop"—a collection of exhibits and fascinating stunts with which he can entertain visitors. Items for this shop can be both permanent displays and tricks that can be performed with the minimum of preparation. A few suggestions follow, but every installment of this home chemistry series contains at least one stunt that could well be included in your repertory of wonders.

A "silver tree" that can either be "grown" before the spectator's eyes or be set up as a semipermanent exhibit will make a beautiful and instructive feature. Merely dissolve 3 grams silver nitrate in 60 ml. distilled water and pour it into a 2-oz. bottle. Carefully clean and scrape a roll of tin foil about 1½" long and ¼" in diameter, and suspend it from the stopper of the bottle. In a few minutes glittering crystals of pure silver will be deposited over the surface of the tin foil. Being chemically more active than silver, tin drives the silver out of the silver nitrate and replaces it. The crystals of silver keep growing until all the silver in the solution has been replaced. They will remain on the tin-foil core until jarring dislodges them.

A miniature flag that responds as a humidity indicator, and may be changed



Here is a puzzler guaranteed to make spectators gape. A beaker or thin glass containing crystals of ammonium nitrate is set on a damp block of wood. Simply by adding water and stirring vigorously, the beaker can be made to stick tight. As the crystals are dissolved, the beaker becomes intensely cold and the drops under it freeze solid



Colored in a solution of cobalt chloride, this little flag is a bright blue when it is perfectly dry. Blow on it, however, and it turns pink as it absorbs the moisture from your breath. Its ability to register quickly a slight change of moisture in the air makes a flag of this kind an excellent indicator of humidity

from bright blue to pale pink merely by blowing on it, is another stock exhibit that may be made in a few minutes and will always arouse interest. Soak a piece of white cotton goods in a solution of cobalt chloride. While this cloth remains wet, or is even moist from humidity, it will be pink, but as it dries, its color changes to light blue and then to deeper and deeper shades of blue. Mount the cloth on a little flagstaff. Before demonstrating the trick, warm the flag slightly in order to make it the deepest blue. By blowing on it for a minute or so, you can turn it pink as the crystals of cobalt chloride absorb moisture from the breath.

Strips of white paper can be made to turn pink or red when held in what appears to be an empty glass, and then to turn white again when removed. Prepare a supply by soaking strips of blotting or filter paper in phenolphthalein solution and allow them to dry. To work the stunt, moisten a strip in plain water and hold it in a glass that has just been rinsed with household ammonia. In the presence of the ammonia, the phenolphthalein gives its usual reaction to a base, turning pink or red, but returned to fresh air, it loses its color.

A beaker or thin glass containing 60 grams ammonium nitrate will enable you to perform a feat that will get a sure-fire response. Put a dozen drops of water on a wood block and place your beaker in the center of the puddle. Now stir in 60 ml. of water (as cold as you can get it), attempting to dissolve the chemical as quickly as possible. During this process the beaker will become extremely cold and in a minute or two will freeze fast to the block. A thin coating of oil smeared inside the beaker above the solution will allow the water to evaporate eventually of its own accord and keep the chemical from creeping over the top of the beaker. When the crystals are dry, the stunt may be repeated.

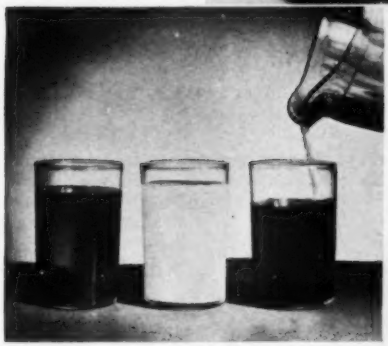
You probably know the dinner-table stunt of boiling water on a visiting card with turned-up edges. The match or candle flame used does not burn the card because the water keeps the latter below the temperature of combustion. With care, tinfoil and lead foil may be melted similarly on a card.

The safety lamp, invented by Sir Humphrey Davy to prevent the explosion of free gas in coal mines, makes use of the same principle. In this case a screen of fine wire gauze surrounding the flame prevents igniting of outside gas by limiting the heat that gets through. A model of a safety lamp can be made from metal netting soldered or sewn to form a tube 6″ long and 2″ in diameter. Fasten on a top of the same material. If copper gauze of 30 or 40 mesh is used, only one layer will be required. Coarser netting, such as ordinary window screen, may require three or four layers. A jar cover forms the base, and a birthday-cake candle the light. Direct a stream of illuminating gas from a small tube toward your safety lamp. The gas will not ignite outside the screening, though it may catch fire within the lamp.

A little ball of steel wool that floats and sinks apparently without rhyme or reason is another good puzzler. Fill a tall tumbler or glass cylinder with a water-clear solution made up of 1 part sulphuric acid and 6 parts water. Compress a little wad of fine steel wool to the size of a marble and drop it into the solution. First it will float because of air trapped in it; then it will sink as the solution penetrates. Suddenly, however, it will rise again, then fall, and go through unpredictable gyrations.

To the chemist, the cause of the rising and sinking is obvious. The iron liberates

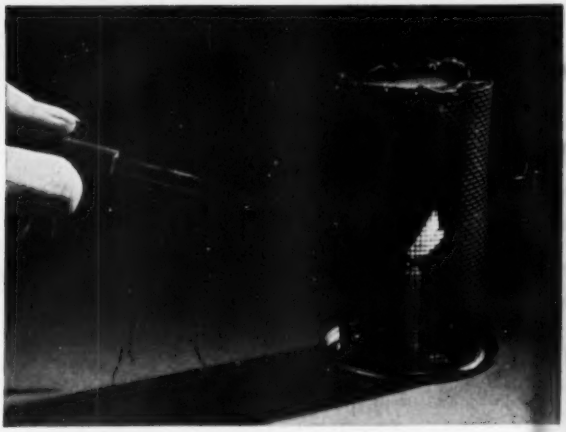
As a finale for your home exhibition of chemical magic, put a little potassium thiocyanate in the bottom of a tumbler, some silver nitrate in another, a few drops of potassium ferrocyanide in a third, and ferric chloride and water in a pitcher. Pour this last into the glasses. The first will become red, the second milky white, and the third blue



hydrogen from the dilute acid. This clings to the ball and buoys it up, but as some of the gas is lost, the ball drops again. If the ball doesn't rise, fluff out the steel wool; if it doesn't sink, compress it further.

For an astonishing—and patriotic—finale, prepare four little dropper-top bottles, each containing a solution of potassium thiocyanate, silver nitrate, and potassium ferrocyanide, and ferric chloride, dissolving 10 grams of each chemical in 60 ml. water. Into the first of three tumblers put 10 drops of potassium thiocyanate; into the second, 10 drops of silver nitrate; into the third, eight drops of potassium ferrocyanide. These solutions are clear and will not be noticed at the bottoms of the glasses. The ferric chloride solution, however, is yellowish, so about 15 drops of it are put into a tinted or opaque pitcher, together with three glassfuls of plain water.

Pour the solution from the pitcher into the first glass, and it instantly becomes red; pour it into the second, and it becomes white; pour it into the third, and it becomes blue!

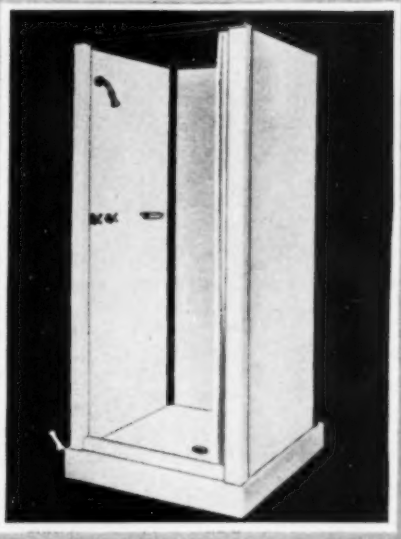


Made of ordinary wire gauze or screening, the little lamp above will demonstrate the effectiveness of the miner's safety lamp invented by Sir Humphrey Davy. A jet of illuminating gas directed toward the flame will cause it to flutter, but will not ignite outside the lamp. The wire gauze cuts down the intensity of the heat passing through to prevent combustion

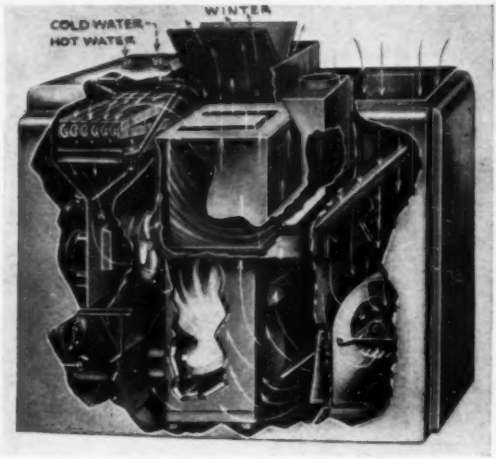
Literally made to grow before the eyes of your friends, the little "silver tree" at right presents a pretty sight. It is a small roll of tin foil in a solution of silver nitrate. Tin is more chemically active than silver, and suspended in the solution it replaces the silver, which is deposited on the roll in glittering crystals as it is freed. This continues until all the silver is used up

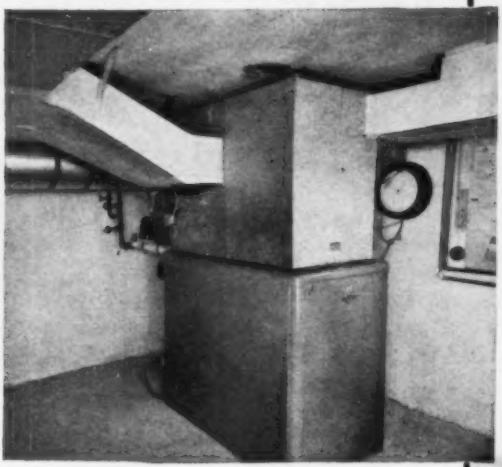
GARDEN TOOL SHEDS prefabricated of insulating wallboard for quick assembly are waterproof, fire resistant, and vermin-proof. They consist of seven parts, including four walls, a floor, and a two-part roof. There are three sizes, from 4′ by 6′ to 10′ by 12′, and they can be used on the beach as cabanas or as back-yard playhouses for children.

NEW SHOWER CABINETS are made of noncritical materials for quick assembly on the job. The cabinet has less than one pound of metal in it. All walls are made of hard pressed wallboard covered with baked enamel resistant to high temperatures. The receptor is made of green plastic. Complete equipment is included with the cabinets, even to the curtain.



COOKING ON GLASS proves quite practical with this portable grate and grill. It is made of glass that has been fired black, powdered to a fine dust, then molded into the grill and basket grate. A folding frame made of wood is coated with fire-resistant glass to render it safe from flame. The grill surface measures 12″ by 19″. Any kind of fuel may be used, although charcoal is, of course, ideal for the purpose.





HOME HEATING may be revolutionized by a new furnace recently invented by Corporal Harry Giffords of the Army Air Forces. The automatic unit furnishes hot water the year around, heats and circulates air in cold weather, provides circulation of outside air during hot days, and filters the air at all times. One of the unusual features of the operation of this unit is that it imparts heat from heated air to water, and uses the water so heated to furnish the domestic hot-water supply.

In summer the unit heats air that in turn heats water for storage or for immediate use without interfering with the circulation of cool outside air. An artificial cooling unit can be added if desired. The furnace is said to be economical to operate. Its principle has been suggested for possible use on large postwar air liners.

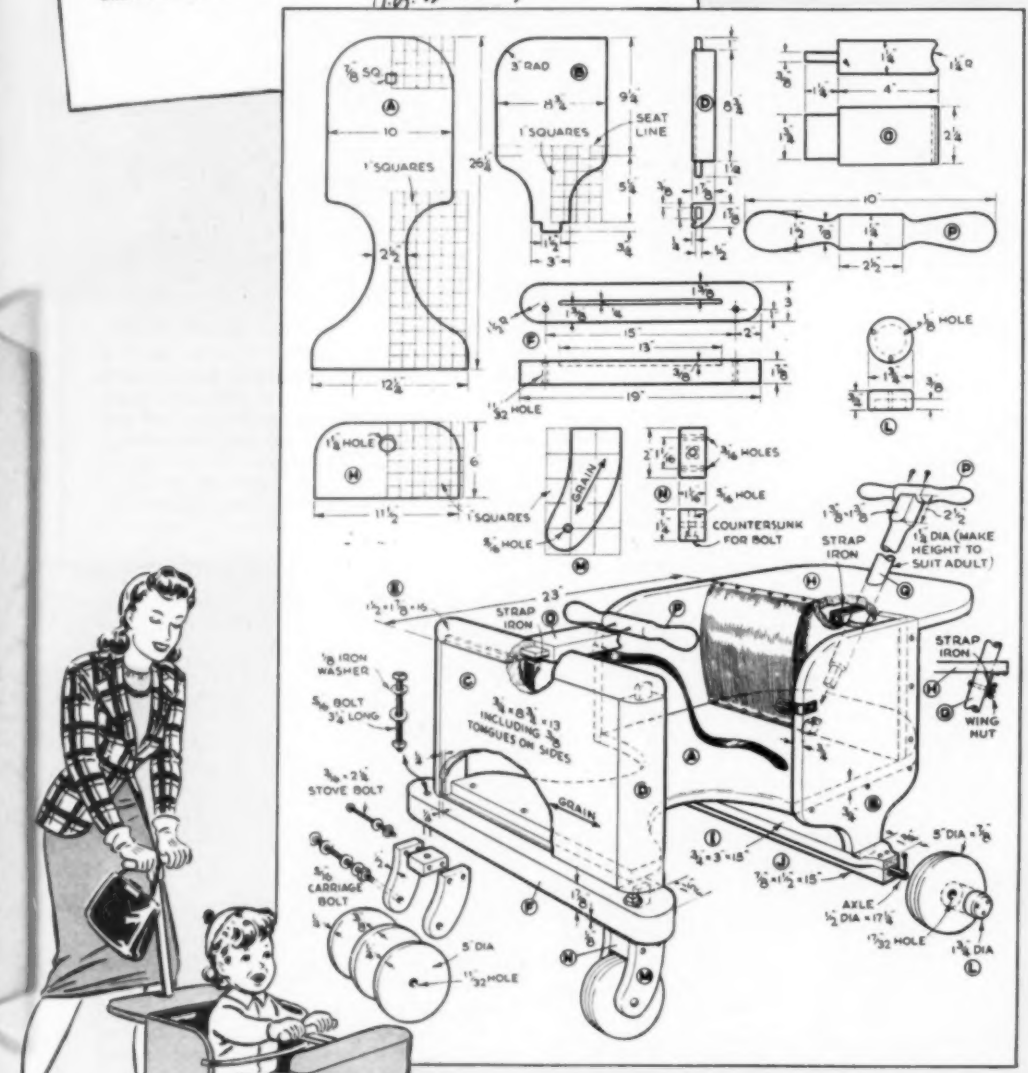
PRESERVING METAL that is about to rust through and become useless, such as gutters on a house or water buckets, is a simple matter with a new solution. The metal is cleaned of rust and dirt to begin with; then the solution is painted on, leaving a thick coat. This liquid is noninflammable and can be used indoors or outside. Objects treated with the solution should be allowed a week to dry, after which they may, if desired, be painted with any good-quality oil paint.

COMBINATION LADDER. A compact ladder that folds small enough to go into the luggage compartment of a car can be used as a long extension ladder, a small or a large stepladder, or as a support for a scaffold. In the photo above one such ladder is shown extended and another in use as a stepladder. The rails and rungs are of hardwood. Rigidity in all positions is assured by a patented double-lock design.

Dear Workshop Editor

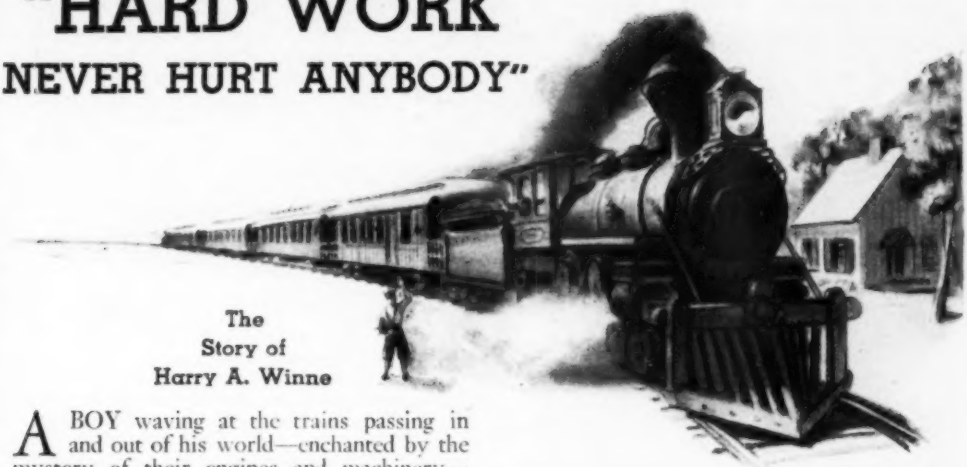
We have a sturdy one-year-old who is about ready for a baby walker, but they're just not to be had in our town. Could you publish plans for a walker that I could build in my home shop?

D. R. Williams / Rockford, Ill.



This walker, by Franklin H. Gottshall, can easily be altered to suit makers' tastes. Thus if it's used as a stroller, a detachable floor might be devised to keep the child's feet off the ground. Be sure that the grain of each wheel disk is 120 deg. from that of the other two disks. Don't finish with white lead paint, since it might be poisonous for teething children

"HARD WORK NEVER HURT ANYBODY"



The Story of Harry A. Winne

A BOY waving at the trains passing in and out of his world—enchanted by the mystery of their engines and machinery—that was Harry A. Winne.

He just *had* to know what made their wheels go round, and he was about knee-high to a brakeman when he started to learn. He'd hurry home from school to run the steam engine in his father's laundry. Soon he tore a small magneto apart and from it built an electric motor.

He knew he was going into the electrical business somehow; he thought maybe he'd become a lineman for an electric power company. So he and a blacksmith made metal climbers, and he learned to climb the telephone poles outside the grocery store where he was clerking.

But the teachers in the upstate New York town urged him to go to Syracuse University to study engineering. So Harry Winne started working harder. Summers he worked in a creamery; at other times he delivered the college newspaper and was Sunday watchman at Woolworth's. Studying as hard as he worked, he was graduated at the head of his engineering class in 1910.

At once he joined General Electric as a student engineer in the testing department, Schenectady. There he could watch some of the biggest wheels in the world go round, and in two years he was made assistant general night foreman.

"There are things higher up for you, Harry," his boss said before long. "You've got everything you can get here. You're destined for higher things."

And up Harry Winne went—through various engineering departments, to head of the steel mill section in G.E.'s industrial engineering department, to manager of sales of the combined mining and steel mill section—and then finally, a couple of years ago, to vice president in charge of design engineering!

Harry Winne'd tell you he got up there by hard work and luck. Today he's working harder than ever—at G.E. supervising the design of electric equipment for the army and Navy, at home in a big Victory garden beside his made-over farm house on a dirt road outside Schenectady.

But then—"hard work never hurt anybody!" *General Electric, Schenectady, N. Y.*

Hear the General Electric radio programs: "The Hour of Charm" Sunday 10 p.m. EWT, NBC—"The World Today" news, every weekday 6:45 p.m. EWT, CBS.

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HW 571

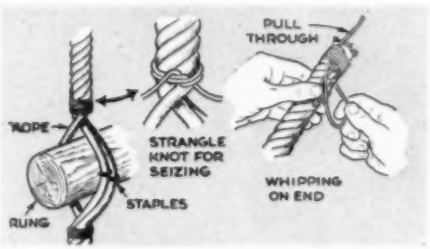
Easily Made Rope Ladder Is Useful Emergency Equipment

Wrapping an arm and a leg around a rope ladder gives support to the body in climbing. At right are shown details in the construction of a ladder

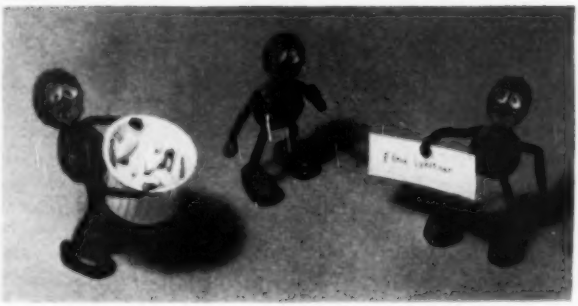
WHEN an emergency strikes, rope ladders are often highly desirable equipment, since they may be quickly put in position and are not hard to use. A feature which makes them especially convenient is that they can be rolled up for compact storage. They are also handy for access to a loft or attic where room does not permit installing a stairway.

These ladders are easily made from strong rope, 18″ lengths of oak 1¼″ in diameter, and twine. The rope may be used in two pieces or doubled. Unlay the strands at equally spaced intervals 12″ to 18″ apart, insert the rungs, allowing 1″ to protrude, and hold them fast with staples. Bind twine above and below the rungs.

Whip the rope ends by forming a circle of a 15″ length of twine, with ends overlapping 2″. Hold it against the rope so that one end projects a little beyond the rope end. Wrap the side of the loop which extends beyond the rope back around the rope. When the loop has diminished, hold as shown and pull on the projecting end of twine. Then cut off the loose ends.—WILLIAM H. DAVIS.



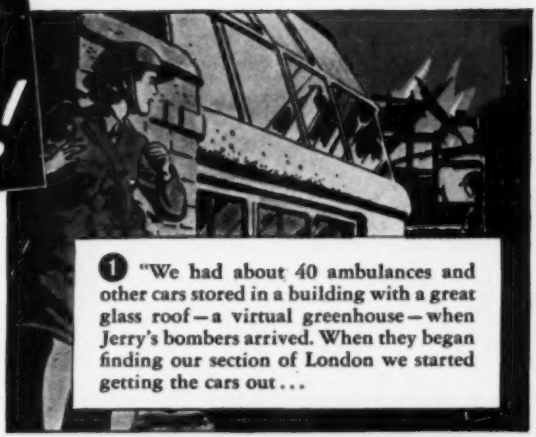
Perky Halloween Hobgoblins Are Created from Black Walnuts



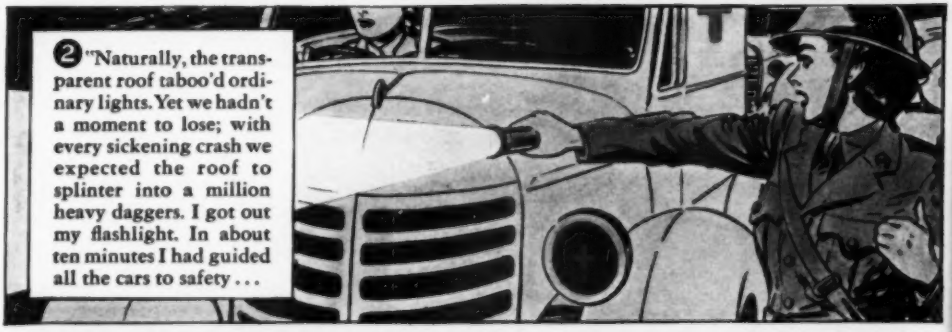
CAPTIVATING little hobgoblins for Halloween decorations may be made from a few black walnuts and pipe cleaners. Cut off a portion of the tapered end of the walnut so that you may use the exposed cross section for the face. The simplest way to do this is to hold the nut in a vise and cut it with a coping saw. Dig the meat from the two natural eye holes and fill the cavities with wood putty. After the putty has hardened, paint a little pupil on a part of each eye. The natural formation of a black walnut will give the illusion of a nose and mouth. Saw out the hobgoblin's big feet from ½″ stock and drill holes in the head, body, and feet. Attach the head and feet to the body with pipe cleaners and glue, allowing the glue to set before painting all but the face with mahogany oil stain. The little fellows will serve to hold nut cups and place cards if their pipe-cleaner arms are bent properly. They may also be placed around the room as Halloween decorations.—E. W.

BLITZED IN A GREENHOUSE!

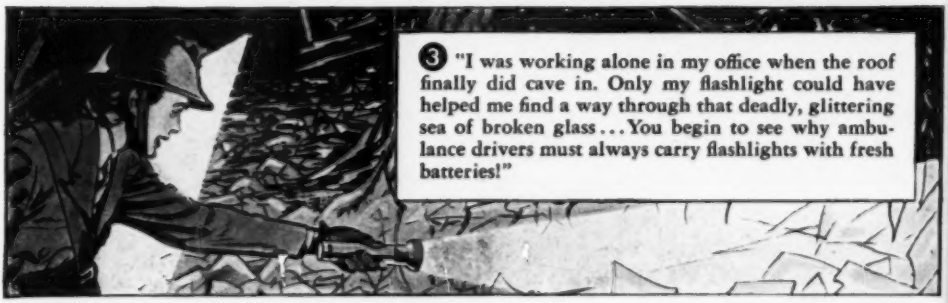
(The exciting experience of Margaret Bridges, of the London Auxiliary Ambulance service, during one of London's heaviest raids. Pretty, attractive 30-year-old Miss Bridges is part English, part American. She volunteered for the ambulance service, reporting for duty just three days before war was declared.)



❶ "We had about 40 ambulances and other cars stored in a building with a great glass roof—a virtual greenhouse—when Jerry's bombers arrived. When they began finding our section of London we started getting the cars out...



❷ "Naturally, the transparent roof taboo'd ordinary lights. Yet we hadn't a moment to lose; with every sickening crash we expected the roof to splinter into a million heavy daggers. I got out my flashlight. In about ten minutes I had guided all the cars to safety...



❸ "I was working alone in my office when the roof finally did cave in. Only my flashlight could have helped me find a way through that deadly, glittering sea of broken glass... You begin to see why ambulance drivers must always carry flashlights with fresh batteries!"

Your dealer may have no "Eveready" flashlight batteries. If so, please don't blame him—almost the entire supply is currently going to the armed forces and those war industries with the highest priority ratings.

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FRESH BATTERIES LAST LONGER... *Look for the* DATE-LINE

Buy War Saving Bonds and Stamps regularly.

HW 573

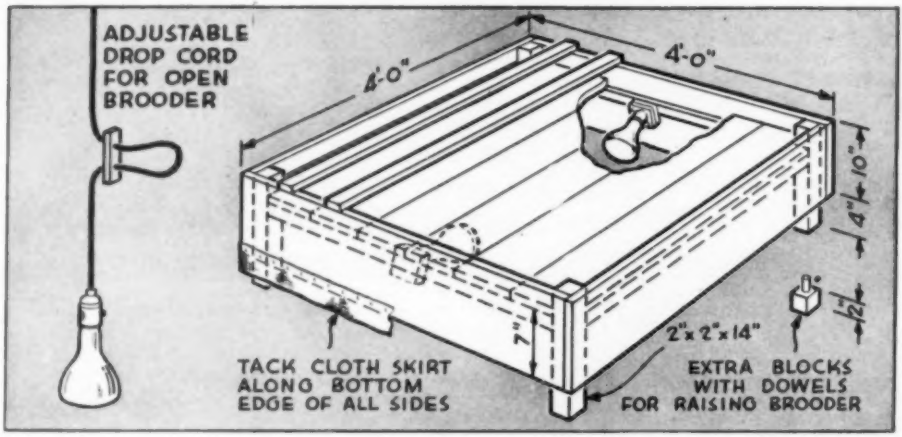
Homemade Brooder Uses Infrared Lamps as Source of Heat

WITH factory-made brooders hard to get, poultrymen may need homemade equipment to increase chick production. Shown below is a simply built brooder of 250-chick capacity which will let you raise "spring" broilers at any season, and which costs only $3 to $7 for materials. It was designed by Professor John E. Nichols, of Pennsylvania State College.

The brooder is made of ⅞" by 10" stock, with legs 2" by 2" by 14". Set the inside cleats 11" from the ground, and nail on them a flooring of 10" stock, 4' long. You will then have two shallow compartments, the lower one giving about 4" ground clearance. Fill the upper compartment with floor litter to serve as insulation, and tack a cloth skirt to the sides. Slats can be nailed across the top so that the brooder may later serve as a roost for older chickens.

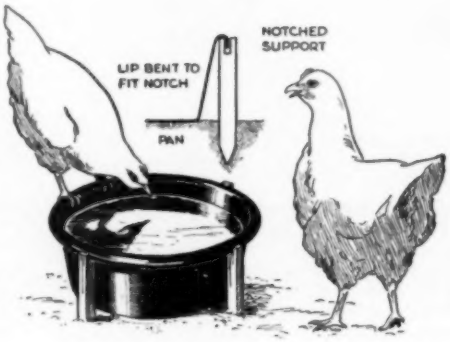
On facing inner sides of the lower compartment set two porcelain lamp sockets, and bore a ⅜" hole for the cord. A strip of wood under the upper edge of each socket base will give the lamps a desirable downward tilt. Be sure to use heavy-duty wire in connecting the sockets. The lamps are 150-watt reflector-flood types or 250-watt reflector-drying types, with rated lives of 1,000 and 5,000 hours respectively. These lamps, which project infrared heat rays as well as light, are especially suitable, although ordinary incandescent bulbs can be used if reflector types are unavailable. A thermostat is not needed with the former, since the chicks can find the right heat for their needs, but is desirable with ordinary bulbs.

An even simpler brooder for 200 chicks or less can be built by forming an uncovered enclosure of wood or light sheet metal and suspending one or two reflector bulbs over the area. Start with a lamp about 12" above the brood and raise it with the handy wire shortener as the chicks grow.



Wood Supports Keep Chickens from Upsetting Water Pan

CHICKENS perching on the side of a water pan will frequently upset it, particularly when the water level is low. A simple and practical method of preventing this is to use three notched supports as shown in the drawing to the right. Saw kerfs in the tops of three wooden stakes, sharpen the opposite ends, and drive them into the ground in the proper position. It may be necessary to bend the lip of the pan somewhat so that it fits the notches snugly.—JOHN K. KARLOVIC.



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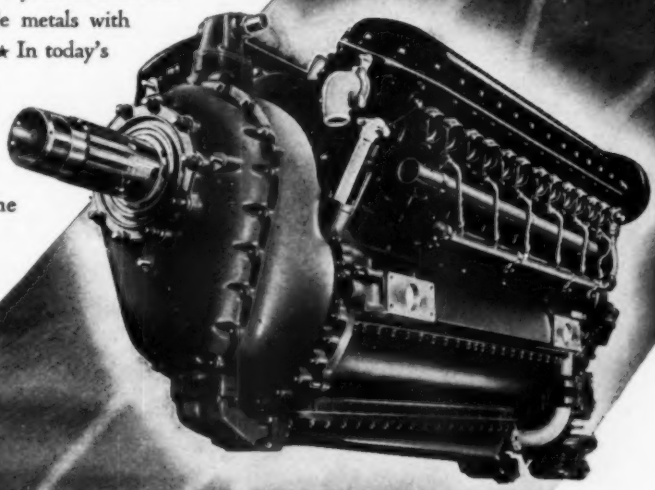
Like mirrors and jewels is the sparkle of polished metal parts in an Allison—but the eye cannot begin to see the perfection this brilliance reflects. ★ For one of the challenges in making aircraft engines is this . . . ★ To preserve — by exquisite accuracy of manufacture and finish — all of the inherent strength and endurance in every ounce of material used. ★ This need for perfection is nothing new to Allison. For years it has been our special province to handle metals with precision and lapidarian skill. ★ In today's tasks we are advantaged by all that General Motors has to offer in production techniques. ★ The result is a liquid-cooled aircraft engine which in performance can speak for itself—and an engine which we are resolved to make the finest in the world.



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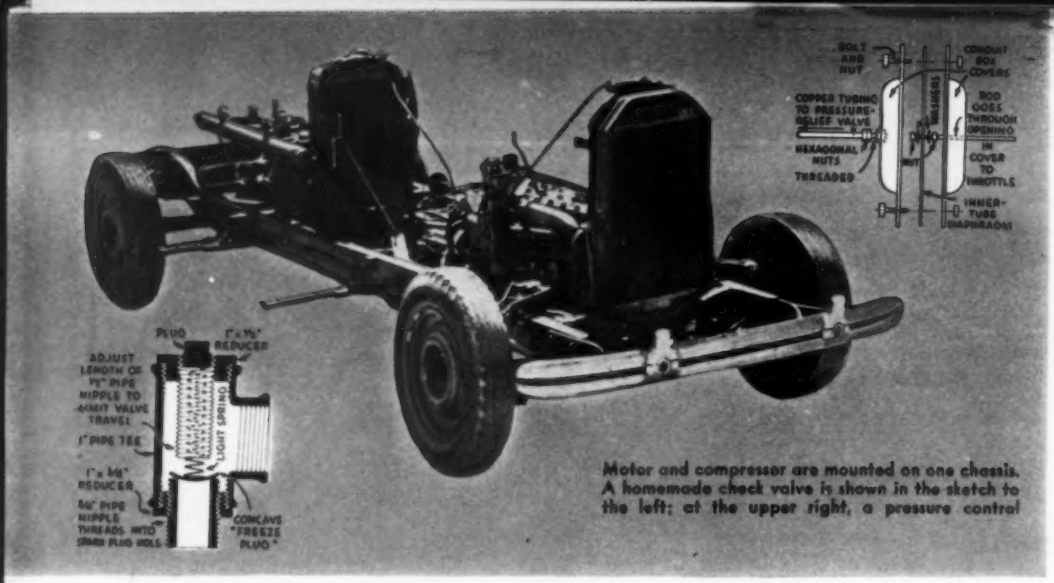
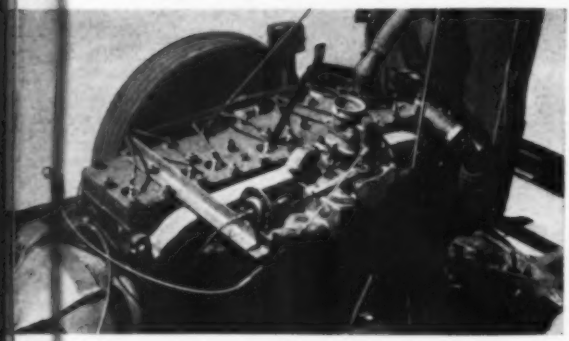
HW 575


BOLT AND NUT
CONDUIT BOX COVERS
COPPER TUBING TO PRESSURE-RELIEF VALVE
WASHERS
ROD GOES THROUGH OPENING IN COVER TO THROTTLE
HEXAGONAL NUTS THREADED
INNER-TUBE DIAPHRAGM
PLUG
1" x ½" REDUCER
ADJUST LENGTH OF ½" PIPE NIPPLE TO LIMIT VALVE TRAVEL
LIGHT SPRING
1" PIPE TEE
1" x ½" REDUCER
½" PIPE NIPPLE THREADS INTO SPARK PLUG HOLE
CONCAVE "FREEZE PLUG"

Motor and compressor are mounted on one chassis. A homemade check valve is shown in the sketch to the left; at the upper right, a pressure control

HEAVY-DUTY AIR COMPRESSOR



The throttle of this motor is controlled by a rod from a pressure unit that was made by bolting together two conduit boxes over a rubber diaphragm

On the compressor, below, the throttle control rod is moved by a vacuum overdrive unit, but the type used with the engine would have been satisfactory. The radiator is needed to keep the compressor cool

AIR compressors can't be bought readily today, so when a mining company needed one, Henry Lawrence, of Santa Fe, N. M., built it from two wrecked cars. A motor from one is used to drive a compressor made from the other motor.

To convert the motor to a compressor, Lawrence removed the valve lifters and installed light springs on the valves. This enables both the intake and exhaust valves to feed air to the cylinders, and makes each upward stroke a compression stroke. To filter all the air through the carburetor air cleaner, the exhaust manifold was closed off and an inner wall broken through to the intake manifold.

Studs were screwed into the firing chambers in the cylinder head and lead was poured around them to increase compression. Homemade check valves were screwed into the spark-plug holes. Each was made of a pipe tee, the valve proper consisting of a concave expansion plug such as is used to safeguard engine blocks against freezing. A check valve in the air manifold also keeps air from feeding back.

Two homemade control units govern the machine. The air chambers in the control units are connected with a hot-water tank relief valve set on the air tank. When pressure reaches the point for which this valve is set, the control diaphragms move rods attached to each carburetor. This reduces the engine speed to idling and also cuts off the compressor air intake so that it "coasts." A pinhole in the air line to the control units allows the pressure to bleed out slowly. Then both throttles open and pumping continues.—EUGENE S. HARRIS.

"FIRE BOMBS FALLING ... Rush the Pumpers!"

It's a forward base for the big push . . and the Japs know it. They're trying to burn us out. For a while it seems we have more fires than we can handle . . that is, till the fire pumpers arrive. They're hauled by anything that will pull! They unlimber and go into action like artillery. Fire just hasn't a chance with them around!

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CLEANS OUT MOTORS • KEEPS MOTORS CLEAN

New Theory of Air Power

(Continued from page 52)

equipment. An Air Support Party—sometimes a single liaison officer—is attached to a field unit, such as a regimental combat team.

These men funnel the inflowing mass of information, strain out what is important, pass on what the ground commander should know, and expedite requests for air support at specific places and times. Their work must be cool, unhurried, yet rapid and precise. The plans they draw up and the orders they give tell the story.

The complexity of air support, the fluid brilliance with which it functions in battle, is almost impossible to visualize without seeing it in action—and few civilians ever can have the chance to see it. Even the war correspondents who get behind the scenes of military operations are barred by security regulations from describing the technical workings of the machine.

To give a clear, dramatic picture of air support, POPULAR SCIENCE, with the cooperation of Army Intelligence sources, has arranged an account of one day's air-ground operations on a divisional front. It is accurate in every detail, although the description is sufficiently generalized that no information can be revealed to the enemy.

The opposing forces are facing each other along a line lying roughly between the town of X and Unknown River. Our forces are attacking to the north, while the enemy, giving ground slowly, is attempting to hold south of the river. At dark our troops have been stalled by stubborn resistance. The division commander has decided that he must lean heavily on air support in the next day's fighting.

The battle plan is set up at a conference in the tent of the chief of staff. Attack is to be resumed in the morning, with Combat Team X making the main effort on the left. Team Y will hold the right flank and Team Z will be held in reserve. The first need is for thorough air reconnaissance far behind the enemy line. The second is for heavy air support, as most of the artillery will have to be concentrated on a relatively narrow front in support of Combat Team X.

Air Commander recommends continued pressure to keep the enemy air force pinned down, plus a heavy bombardment of key rail lines. As for the direct support of the attack, that is a matter of careful timing. The infantry push is scheduled for 0615, preceded by a 10-minute artillery barrage of maximum violence, beginning at 0600.

(Continued on page 204)

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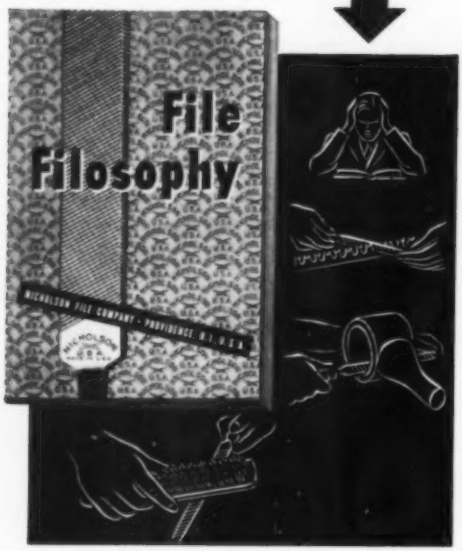

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New Theory of Air Power

(Continued from page 202)

Air support is to strike at precisely the interval, hitting at 0610 with a low-level attack by six A-36 Mustang fighter-bombers. Two minutes later the pounding will be taken up by another flight of six A-24 dive bombers.

As an indication of the precision with which air and ground operations are integrated, the artillery barrage will end with the firing of smoke shells to mark the objective for the diving planes; the last dive bomber gives the infantry the signal to go ahead by waggling its wings. Our own front lines will be marked with colored smoke to obviate any danger of an error in bombing objectives.

The chief of staff okays these arrangements and orders the necessary reconnaissance and photographic air missions to be worked out with the G-2 (intelligence) officer. Next comes a conference in the Air Support Control office, usually located near the divisional command post. The G-3 (operations) officer explains the plans for ground operations, while the Air Commander outlines his operations to the liaison officers of the various air groups — reconnaissance, dive bombers, medium bombers, and fighter planes.

The complex process of mounting a coordinated air-ground operation moves along as the air support and divisional signal officers go into a huddle of their own, check over their wire and radio communications, shift some of the radio frequency bands which are jamming up against powerful enemy transmitters, and arrange a code of visual smoke and panel signals. Finally, the Air Commander is ready to issue his attack and operations orders, which are teletyped to the airdromes over the A-2 wire net.

At dawn the attack begins, with a thundering artillery barrage pouring down on the hill which is the enemy's chief point of resistance. With split-second timing, at 0610, the artillery fires its smoke shells, the infantrymen set off red smoke to mark our advanced lines, and out of the low-hanging mists roar the A-36 Mustangs, to strike with their bombs, then vanish. Immediately the Douglas Dauntless A-24 dive bombers arrive, peel off one by one, and smash at the target. As the last plane gives the signal by rocking its wings, the infantry attack is launched.

While the ground fighting grows in intensity, the planned air operations go ahead with attacks on enemy air fields and supply

(Continued on page 208)

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IN CIVILIAN TRANSPORTATION. War workers depend on their own cars in driving groups to get them to and from work, and everyone knows Champions are a dependable source of efficiency and economy.

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BACK THE ATTACK — WITH WAR BONDS

There's been a big change

● Sentiment about the old things is an admirable American trait. But even the most sentimental of us must admit that change frequently is for the best.

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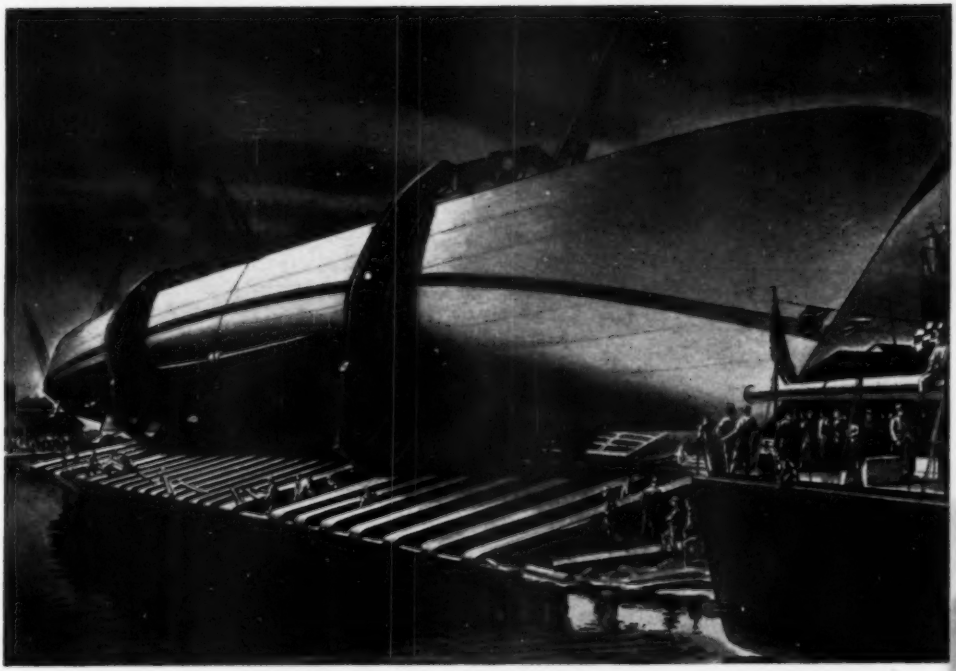
TODAY'S HEAVY-DUTY BEARING

★ BACK THE ATTACK — WITH WAR BONDS ★



750 Ton Flapjack!

HISTORY was made when the destroyer escort, U.S.S. *Bunch*, was "rolled over" successfully at the Defoe Shipbuilding yards at Bay City, Michigan. For this was the first time a steel-welded ship more than 300 feet long and weighing over 700 tons had been built upside down.

The same engineering feat that made it possible to build the U.S.S. *Bunch* in record time is producing an ever increasing fleet of sister ships—many of which are already in service with the Navy on the high seas.

Defoe's unique "flapjack trick" with ocean-going warships does away with conventional ship scaffolding and allows workers to stand over their job at all times. Defoe construction methods deliver *twice the production per man hour* resulting in *double the number of ships* built at *half the labor cost per vessel.*

"Next to our immediate task of building warships faster and faster, the first responsibility of Defoe is to plan for post-war operation that will provide the maximum of gainful employment."

HARRY J. DEFOE
Founder Defoe Shipbuilding Co.

Resourcefulness in developing new methods and shortcuts to speed delivery of ships to the Navy is typical of Defoe engineering tradition. And when our fighting men and their allies have dealt a knockout to the Axis, the same competitive spirit, skilled workmanship and "know how" that are now setting records in producing for Victory, will be reflected in even greater values of Defoe products to serve peacetime America.

★ ★ ★

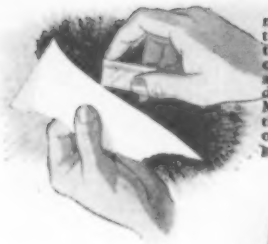
BACK THE ATTACK—BUY WAR BONDS
Defoe workers take more than 10% of their pay in War Bonds

DEFOE SHIPBUILDING COMPANY, BAY CITY, MICHIGAN

Two White Star Renewal Citations now decorate the Navy "E" Award won by Defoe workers.

Defoe

Ships for Victory
Servants for Peace



If you can imagine measurements to a fraction of the thickness of this sheet of paper, you can visualize tolerances allowed in Stevens' production of military rifles. Measurements as fine as this are made thousands of times each day with gauges that measure to one ten-thousandth of an inch.

PRECISION ... to a FRACTION of the thickness of this sheet of paper!

The production of military rifles of infinitely precise and dependable mechanism, and in huge volume, is the kind of job with which Stevens has long been familiar.

Before the war, Stevens produced sporting arms in great quantities. Yet the technical skill and facilities employed called for the most painstaking and precise methods of gun-making and assured a high degree of accuracy, safety and reliability in all Stevens-built rifles and shotguns.

Stevens long offered exceptional values from the standpoint of basic gun quality and comparatively low price. When the war is won, Stevens will repeat this performance, with the greatest rifle and shotgun values in our history.

J. STEVENS ARMS COMPANY
Division of Savage Arms Corporation
Chicopee Falls, Mass.

STEVENS

New Theory of Air Power

(Continued from page 204)

lines. About 10 a.m. full reconnaissance reports and air photographs from 30,000 feet reveal an alarming development. A heavy enemy striking force, including 100 tanks and additional armored and supply vehicles, is moving up on the rear roads, clearly heading for the point of our main attack.

Meanwhile the infantry advance has run into terrific opposition at the contested hill, and has been stopped dead in the woods at the foot of the slope by heavy fire from mortars, machine guns, and 77-mm. field guns. The infantry commander has learned that he cannot get any additional artillery support, and has sent a hurry call for help to his accompanying Air Support Party officer, who radios Air Control to ask what missions might be assigned or diverted to help pull the situation out.

Here air command has two new and pressing problems. The enemy-held hill needs our attention; so do the approaching tanks. But ground-force headquarters must determine the relative priorities involved, and the division chief of staff unhesitatingly puts the tank column first. A reserve squadron of B-25's (North American Mitchell medium bombers) is ready, and is ordered into action through the flexible system of control.

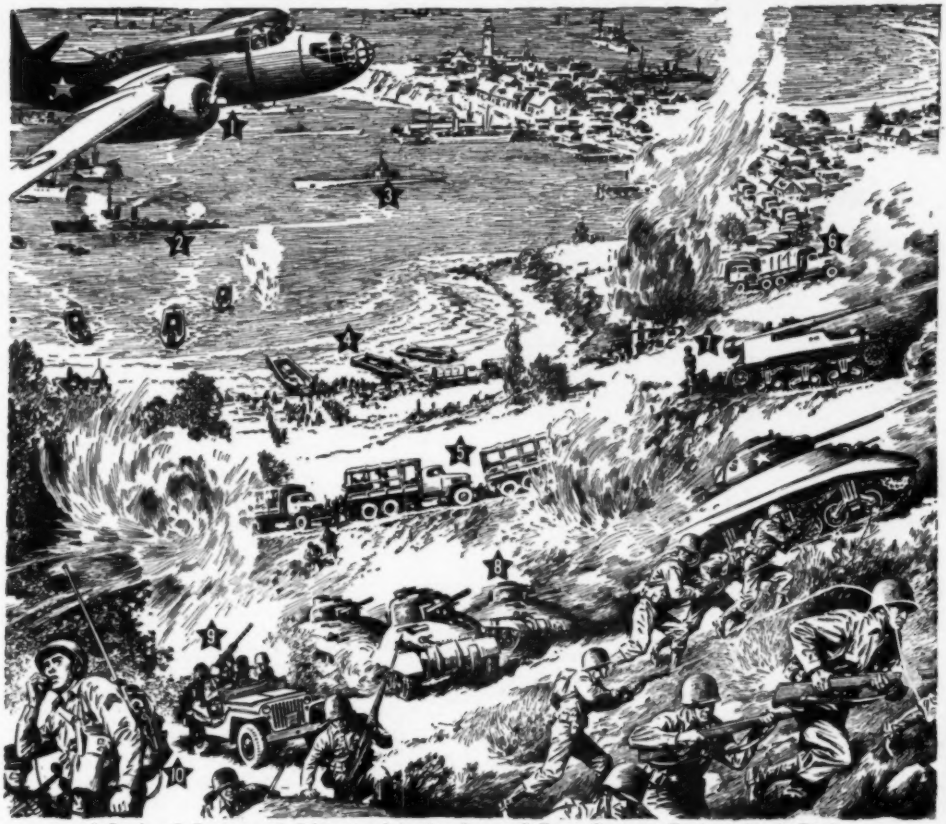
Photo maps and latest reconnaissance data are hastily assembled, and the crews file into their field headquarters for briefing—an informal but deadly serious process. The youthful squadron leader explains casually that "our doughfoots are in a jam, and it's up to us to deliver a low-level attack that will stop a column of enemy tanks. They're getting too close to a spot that's already too hot."

He shows them the map point where they will take formation, echeloned to the right. The attack will be pressed home at extreme low altitude, with intervals of 2,000 feet. "Give 'em your forward guns on the way in, and release all bombs in train." Fighter escort is arranged with a near-by field. The combat crews pile into jeeps and trucks and roll out to their planes, scattered around the dispersal area.

The tank column, rolling south at 20 miles an hour, is attacked at "zero-plus altitude." The first B-25 sweeps in over the trees, its guns blazing, and cuts loose with its bombs, which have delayed-action fuses set for the planned attacking interval so that they will explode just after the plane is out of the way and before the next attacker slashes by.

(Continued on page 210)

Without batteries...war machines are useless!



1. Bomber 2. Destroyer 3. Submarine 4. Landing Barges 5. Troop Transport Trucks 6. Supply Trucks 7. Self-propelled 155 mm. Gun 8. Tanks 9. Jeep 10. "Walkie-talkie" communications

EXIDE BATTERIES ARE USED IN MORE THAN 100 APPLICATIONS BY OUR ARMED FORCES

Modern mechanized warfare demands a dependable source of electric power, which, under most conditions, only a storage battery can supply. Without such a source of power, our mightiest weapons would lie useless, idle, dead.

Supplying dependable storage batteries to the armed forces is Exide's most important present day job, and you as a civilian motorist can help us provide America's fighters with more and more of them. You can do this by giving your present battery the very best of care. Let your Exide Dealer check your battery every two weeks. Trust him, and his dependable Exide Sure-Start Service, to prolong its useful life.

Remember, when you take care of things you own, you're really making important savings. Invest your savings in War Bonds.

Back the attack—with War Bonds!

Exide
BATTERIES

WHEN IT'S AN EXIDE *YOU START*

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia • Exide Batteries of Canada, Limited, Toronto

Avoid those "Icicle evenings"

PROTECT HOME COMFORT WITH BALSAM-WOOL ATTIC INSULATION

Tooth-chattering "evenings at home" aren't fun! But there's no need to endure chilly, uncomfortable rooms. At low cost, you can make your home far more comfortable—and save up to 20% in fuel at the same time—by applying Balsam-Wool Insulation in your attic.

Applying Balsam-Wool is as easy as laying a carpet! That's because Balsam-Wool is a finished insulation—tailored for quick application. Windproof, moisture-proofed and fire-resistant, it is scientifically designed for lasting efficiency—and sold under a *money-back* guarantee of satisfaction.

Make this lasting investment in comfort and fuel saving. See your **lumber dealer** about applying Balsam-Wool in your attic—or mail the coupon for full information.

Balsam-Wool
SEALED INSULATION

WOOD CONVERSION COMPANY
Dept. 211-11, First National Bank Bldg.
St. Paul, Minnesota

Gentlemen: I want to know more about Balsam-Wool Double Value Attic Insulation.

To assist us in giving you special information, please check: I am a home owner ☐, renter ☐, architect ☐, student ☐, contractor ☐.

Name.....

Address.....

City..... *State*.....

New Theory of Air Power

(Continued from page 208)

The formidable armored column disintegrates into a wild, scrambling mass of vehicles and men. Within 10 minutes the road is strewn with burned and blackened equipment, and the pummeled remnants of the enemy force are withdrawing in total confusion.

Meanwhile, air support is working on the problem of the enemy hill. No other reserve flight is available, so bombers must be diverted from a planned operation to take up this emergency job. By means of radio equipment and a secret technique, the air support command "vectors" a squadron of bombers on their way to blast enemy railroad yards behind the battle, and steers them to the new target. They wing in, drop a blanket of destruction on the enemy strong points and artillery emplacements, and clear the way for the combat team to push ahead, carry its objective, and then drive on to the river crossing against steadily deteriorating resistance in the late afternoon.

For air operations the day ends with the return of the planes and systematic interrogation of the crews to determine the results of their attacks. This is done at the air fields, where the airmen gather at the squadron intelligence officer's office, make themselves comfortable with coffee and cigarettes, and then answer the long routine of questions on what targets they hit, what effect the bombs had, what air opposition or ground fire they encountered, what the weather was like, and so on and on.

But the day ends only in the sense that this information is summarized and reported on to the higher command, which starts at once to plan the air support for the next operation—only a few hours away. This, in capsule form, is how air support works. And what it means to the ground forces was best summed up by the Allied field commander in Tunisia, General Sir Harold Alexander, in this message to the African Tactical Air Command:

"Without your support this drive would just not have been possible."

NOTICE TO SUBSCRIBERS

Subscribers in the armed services who notify us of change of address are requested to give us the key symbols appearing on the wrapper in which the magazine is received.

Harley-Davidsons are Really *Standing Up!*

On all war fronts, the men who ride and service Harley-Davidsons are learning what "dependable performance" really means. You can't beat tough war action for proving that Harley-Davidsons can "take it and dish it out."

One fighter wrote from (CENSORED): "We're in an ordnance maintenance outfit and I'm overhauling trucks, cars and small engines. Harley-Davidsons are really standing up. They get twice the mileage and abuse other vehicles get before they need attention. I intend to get a new 74-OHV Harley-Davidson when I get back to the good old U. S. A."

Hundreds of these letters continue to pour in—and the story is always the same. Put your fighting dollars in War Bonds — and join the riders who are going to own newer, better Harley-Davidsons after the war!

HARLEY-DAVIDSON MOTORCYCLES

HARLEY-DAVIDSON MOTOR CO.
Dept. PS, Milwaukee 1, Wisconsin

Please send at once free copy of 24-page "Enthusiast" Magazine, filled with motorcycle action pictures and thrilling stories.

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SEND COUPON NOW

FREE!

Tool Tips by STANLEY

Know How to Sharpen Plane Irons or Chisels

Unnecessary grinding of chisels and plane irons wears them out prematurely. If they have simply become dull in use, whetting will restore the sharp, keen edge desired.

GRIND THEM *ONLY* WHEN

1. **The cutting edge is nicked.**
2. **The bevel has become blunt due to whetting at the wrong angle.**
3. **The bevel has been rounded by careless whetting.**

Tools are vital to Victory. Care for them and use them properly – to make them last for the duration – to avoid waste of scarce metals.

Complete instructions for grinding and whetting edge tools are included in the STANLEY TOOL GUIDE, a 32-page handbook for the home craftsman. Simple explanations, thoroughly illustrated, tell how to use and conserve all types of tools.

A Big Value for only 25¢

Write for your copy today.

STANLEY TOOLS
DIVISION OF THE STANLEY WORKS
106 ELM STREET
New Britain, Conn.

Props for Our Warplanes

(Continued from page 127)

charged engines. If the propeller were, however, able to vary its blade pitch gradually from zero-angle low pitch up to 90 degrees high pitch, it would be flexible enough to absorb the engine's full horsepower at all altitudes. The constant-speed propeller is such a type. The prop and engine act as checks and balances against each other under all conditions of flight.

For emergency operation in the case of multimotored airplanes, this business of changing blade pitch has been carried a step farther to permit the "feathering" of the prop. The blades are turned in their hub through highest pitch until they are edge-on into the wind. The propeller is, of course, useless for thrusting in this position, but feathering is an expedient for flying with one or more engines out of operation, either by design or accident. Four-engined transports frequently cruise on only two of their engines, but this would not be considered good flying practice if full-feathering propellers were not available. Should an engine go dead in an emergency, the prop is feathered into the wind immediately; the prop in this position acts as a brake on the dead engine. In normal operating pitch, the prop would be subjected to "pinwheeling," just as the toy pinwheel spins when held to the wind, and this might result in a damaged engine. All the feathered propeller does is create a drag. A windmilling prop, however, would create more than 20 times this drag. The feathered propeller adds about 1,500 feet to the service ceiling of a twin-engined Douglas C-47 cargo transport flying on one engine and makes the plane much easier to handle. Even a single-engined airplane is at an advantage when fitted with a feathering prop because, in emergency, the plane's gliding range is half again as great with this type as it would be with a windmilling, unfeathered prop.

Carrying the pitch angle beyond the 90-degree feathered position into reverse pitch was a logical step in propeller development made first by Curtiss-Wright. The reversible-pitch prop, which delivers negative thrust, is extremely useful as an air brake. In some instances, it may be used to slow the landing run of planes, but its most practical application is found on multiengined flying boats. Maneuvering a flying boat in the water is, at best, a tricky operation. The reversible prop facilitates maneuvering in general and turning in particular. By reversing the two inboard propellers and

(Continued on page 216)

GREASE for GEARS
but NOT for SHAVING
Grease is great for machines, but men hate to put it on their faces. That is why so many men are switching from ordinary brushless to the new Mennen Brushless Shave – it's a cream, not a grease! Get it in either jar or tube.
MENNEN
brushless
SHAVE
MENNEN
Brushless
SHAVE

A Lift from the Front at Guadalcanal

FOR all its grimness, modern war is merciful to our wounded. The life-giving miracle of blood plasma* . . . the swift, efficient treatment behind the lines . . . plus speedy transport to finely-equipped base hospitals . . . result in an incredibly high proportion of recoveries among even desperately stricken men.

Speedy Transport! It may be by giant transport plane, by ambulance or nimble-footed Jeep . . . or at jungle fronts in the South Pacific, by outboard-driven small craft threading narrow rivers, saving priceless hours between front lines and the base.

Evinrudes are busy at innumerable tasks for the Army and Navy, Marine Corps and Coast Guard . . . driving swift assault boats . . . propelling pontons, lighters, ferries . . . powering huge rubber rafts, wherries, small craft of every type. *After Victory* there will be peacetime Evinrudes worthy of the traditions of their fighting forebears!

EVINRUDE MOTORS, *Milwaukee, Wisconsin*
Evinrude Motors of Canada, Peterboro, Canada

EVINRUDE

OUTBOARD MOTORS

**A pint of your blood can save the life of a wounded soldier or sailor. The need is constant, pressing. Call your local Red Cross Chapter for an appointment.*

MACHINE GUN—built by AC since nine months before Pearl Harbor.

"Sons a Guns"

NINETY pounds of *fire-power*,—that's the .50 caliber Browning machine gun that AC builds by the thousands, night and day.

Manufacturing these guns demands the highest order of split-hair accuracy. Yet, the Army knows that good manufacturing is not enough to keep those guns in trim. So, they are cleaned, oiled, and adjusted in strict accordance with rigid Army requirements.

A Special Message for You

AC has been producing another kind of *fire-power* since 1908. It's the precision-built AC Spark Plug.

The chances are good that you drive with AC's. But, whether you do or not, your spark plugs need to be cleaned and adjusted,—to make them last longer, save gasoline, and improve starting ease.

Your automotive service man can do this for you. He can also give Conservation Service, outlined in the panel below, on the eight other AC products.

Make regular use of this Conservation Service. When replacement is necessary, select AC—for complete satisfaction.

Awarded to AC on September 2, 1942, and renewed June 19, 1943, for outstanding achievement in producing for Victory.

AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION

BACK THE ATTACK—*WITH WAR BONDS!*

SPARK PLUGS—Dirty or worn plugs waste up to 10% on gas. They also cause hard starting, weaken your battery. Have your plugs cleaned and adjusted every few months.

FUEL PUMPS—Practically trouble free. But, if yours has been in use thirty or forty thousand miles, a check-up may be due.

AIR CLEANERS—A dirty air cleaner chokes down the flow of air into the carburetor. Your air cleaner should be rinsed whenever your car is lubricated.

DRIVING INSTRUMENTS—Speedometer, gasoline gauge, oil pressure gauge, ammeter, and temperature gauge seldom need service. But, if they give trouble, have them cared for *at once*.

OIL FILTERS—Slow driving accelerates formation of soot and carbon in engine oil. This dirt will clog piston rings, cause increased consumption of oil and gas. Replace your oil filter element whenever your dealer's AC Oil Test Pad shows that your oil is dirty.

Spark Plugs

Air Cleaners

Fuel Pumps

Oil Filters

Driving Instruments

KEEP THOSE TOOLS SHARP!

WITH sharp tools you can turn out better work—and do it faster! Not only that but sharp tools last longer. And that's important today when your present tools have to do until the war's over.

The easiest way to have sharp tools is to keep them that way—with Carborundum Brand Silicon Carbide Combination Sharpening Stones. They are made with one side coarse and one side very fine grit. Use the coarse side to sharpen very dull tools and the fine side for giving that smooth, keen edge that makes work fun. Ask your dealer for Carborundum Brand Silicon Carbide Combination Stone No. 109.

P.S. And be sure to write for your copy of "Short Cuts to Better Work For The Home Craftsman". It's free for the asking. 100 pages full of practical suggestions and how-to-do-it pictures on how to sharpen tools.

CARBORUNDUM
ABRASIVE PRODUCTS

Dept. S-113

THE CARBORUNDUM COMPANY
REG. U. S. PAT. OFF.
Niagara Falls, N. Y.

(Carborundum is a registered trade-mark of and indicates manufacture by The Carborundum Company)

Props for Our Warplanes

(Continued from page 212)

leaving the outboard props in normal pitch, the pilot of a four-engined flying boat can "come about" in one-fourth the turning radius of a similar craft with conventional propellers.

Under the most favorable conditions, the prop is capable of translating 86 percent of the engine's horsepower into useful thrust, and props have a specific weight of between .22 and .38 pounds per horsepower. (There are only three or four aircraft engines in the world that are known to have a weight-horsepower ratio of less than one pound per horsepower.) It is because there is so little room for improvement that propeller engineers are burning up much midnight oil and energy in their quest for increased power-plant performance.

It has been mentioned that the adaptation of the laminar-flow airfoil section—which holds the stream of passing air close to the surface and cuts down turbulence and drag—to prop blades increased their efficiency, and that engineers have sought to increase the blade area to gain more thrust and absorb the output of higher-horsepower engines. The compressibility phenomenon of the shock wave makes the engineers hesitate to increase blade diameter. Bigger props could be used only if they were geared down to turn slowly enough that the tips would not reach the speed of sound. When an airfoil attempts to exceed this speed, the pressure wave created at its leading edge cannot move ahead of the airfoil. The compressibility cannot get out of the way of the wing or propeller and must be carried along with it, just as the bow wave of a steamer is cast upward instead of outward along the surface when high speed is attained. Unlike the much denser water, the air has nowhere to go and must be dragged along, coating the propeller with tightly packed, turbulent air that does nothing but create such drag that the airfoil loses much of its thrusting ability.

Hamilton Standard engineers increased their blade area without extending the diameter by making the blade paddle-shaped from the shank outward. The paddle blade is wider, with a more rounded tip, and is still structurally strong enough at the shank to withstand the many stresses. There is, however, a limit to the width of the blade. The ability to absorb the engine's power increases directly in proportion to the width of the blade, but, unfortunately, the weight increases with the square of the width.

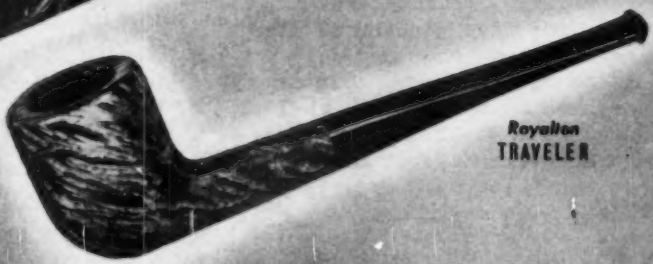
(Continued on page 218)

Buy War Savings Bonds and Stamps regularly.

For Men Who Really Know Pipes

Royalton

Royalton
COMMANDER



Royalton
TRAVELER

Royalton Silver Crown — *Choice Grains* — $5

It's "that little more" that brings success in life. So with pipes. A Royalton adds that extra something to make a good tobacco taste better. Because this greater satisfaction brings enduring pleasure, a knowing smoker and his Royalton are seldom parted.

WHEREVER BETTER PIPES ARE SOLD

© 1943 — Henry Leonard and Thomas, Ozone Park, N. Y.

Dear Jim:

You ought to see

the interest in motorcycles around here. When our outfit comes in from maneuvers the fellows all crowd around asking questions and begging rides. Believe me, our Club is going to have plenty of new riders after the war.

These military Indians are honeys! They take punishment like regular champs -- and they're easy to handle and safe, just as Indians have always been. Wish I could tell you about the new Indian improvements, but military secrecy won't let me. Regards to all the Club members.

INDIAN MOTOCYCLE COMPANY, SPRINGFIELD, MASS.

Indian

BUY WAR BONDS NOW

★ ★ TO BUY AN INDIAN LATER ★ ★

Props for Our Warplanes

(Continued from page 216)

When the blade is made thicker, it displaces more air and builds up compressibility more readily.

There are still other more involved limitations. One of these was the problem of cooling the radial-type engines, since the slip stream, or backwash of air from the prop, is hollow in the middle because of the blades' shape. This was overcome by fitting the blades with cuffs that continue the airfoil shape right down to the hub. This additional surface provides larger thrust area and also brings the hole in the center of the slip stream down almost to nothing. Part of the backwash is then able to enter the engine cowl and contribute to cooling.

The next obvious step in gaining thrusting area was the use of more blades. When planes began to use the bigger engines, the demand for more than three blades forced engineers to solve the vibration problems introduced by four- and six-bladed props. Four-bladed propellers of wood were used in World War I, and were reintroduced by Curtiss in hollow steel form in 1939. Planes that use four-bladed props include the Martin Marauder, Republic Thunderbolt, North American Mustang, and Britain's Spitfire IX (with a British Rotol prop).

The ultimate in props today is the four- or six-bladed dual-rotation job, which consists of two units mounted on coaxial shafts which turn in opposite directions. Even these have been fitted with constant-speed, feathering hub mechanisms by Curtiss, Hamilton Standard, and General Motors, and by Rotol and De Havilland in Britain. They are, literally, two propellers and naturally are heavier than a single prop. But because they can be of smaller diameter and blade width, the weight is not actually doubled but is only about one third greater. The dual-rotation props are worth their weight in performance. First of all, they do away with the evils of torque, or swinging action in flight, since the torque of one set of blades cancels out that of the other unit. Shorter landing gears can be used because of the smaller blades, and this results in a great saving of weight and improved landing behavior of the plane. At speeds around 400 miles per hour, the contra prop increases aerodynamic efficiency more than five percent. The rear prop picks up the whirling slip stream of the forward set of blades and converts it into useful thrust.

The engineers are hard at work on still newer ideas, but the dual-rotation prop will be with us for many years to come.

IT'S THE LITTLE THINGS THAT COU

—and cutting shoes out of skins is one p
cess that calls for skill and perfect vis
The cutter must get the most poss
"cuts" out of each piece of leather—w
still scrupulously avoiding any fla

STYLED for GOOD LOOKS

at "Save for War Bond Prices"

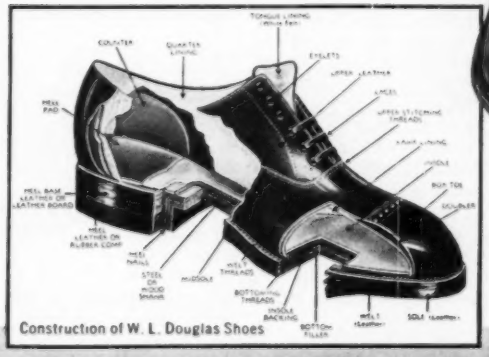
It takes 8 full days—and over 130 separate hand and machine operations—to make a single pair of W. L. Douglas Shoes. It takes accuracy and skill, too, and more patience than you'd think possible. For the experts who make W. L. Douglas Shoes take pride in perfect work—and they aren't satisfied with less.

That's why, today, men everywhere are buying W. L. Douglas Shoes with their ration coupons. That's why *you* should see our new Fall shoes today. They're styled for good looks . . . and priced for honest value.

W. L. Douglas Shoes

W. L. DOUGLAS SHOE CO., BROCKTON, MASS.

Stores in Principal Cities—Good Dealers Everywhere



Construction of W. L. Douglas Shoes

The Commander
A favorite of service men and civilians is this tan plain toe military oxford—Rugged leather sole for all-weather comfort. No. 4565. In Black, No. 4035

The Wing
Handso
moccasin t
oxford in
brown leat
—with Dou
Flex soles
longer wea
greater comfort
No. 4516.

$6.50 $8.50
Other styles at **$5.50**

Douglas "Down-to-the-
construction assures you be

BUY WAR BONDS AND STAMPS FOR VICTORY

HOW TO GRIND CUTTERS FOR WILLIAMS' TOOL HOLDERS

FREE! WILLIAMS' TOOL DATA SHEETS

These two Williams' Tool Data Sheets graphically explain how to grind cutters —give correct included angles, clearances and rakes. Also instructions for set-up and use. Other Data Sheets are listed below. Circle the number of those desired on coupon and mail today. They're punched for 3-ring binder.

1. Characteristics of Williams' "Superior" Wrenches.
2. Data on Williams' Boring Tools.
3. Data on "Vulcan" Chain Pipe Tongs.
4. Data on Williams' "Supersocket" Wrenches.
5. Data on "Vulcan" Lathe Dogs.
6. Data on "Vulcan" Chain Pipe Vises.
7. Data on Williams' Turning-Tools.
8. Data on Williams' "Superior" Wrenches.
9. Saving Time with Williams' "Supersockets"
10. Data on "Vulcan" Eye Bolts.
11. Data on Williams' "C" Clamps.
12. Use of Williams' Cutting-Off Tool Holders.
13. Use of Williams' Knurling Tool Holders.
14. Use of Williams' Threading Tool Holders.
15. Internal Threading with Williams' Tools.
16. How to grind Tool Holder Cutters. Sheet A.
17. How to grind Tool Holder Cutters. Sheet B.

MAIL THIS COUPON

J. H. Williams & Co., Dept. S-1143, Buffalo 7, N.Y.
Please send Data Sheets circled below:

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Name _____

Address _____

City _____ *State* _____

WILLIAMS
SUPERIOR DROP-FORGED TOOLS

"Seeing" the Weather

(Continued from page 95)

Because of the help they might afford the enemy, official weather reports are out for the duration. But there's no reason why you can't learn to be your own weather man. Here are a few simple "hows":

If a summer sky has small cumulus clouds which don't tend to grow larger by noon, you can bank on clear weather.

If you see a bank of cumulus clouds that is growing and building up to a summit, look for rain, hail, and lightning.

If there is a cloud layer over the horizon, and it begins to form turretlike shapes at its top, you are in for squalls.

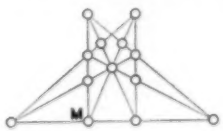
If you see high bands of clouds extending east and west and moving fast, it means that there is a cold snap on the way.

If clouds clot into thick masses and blot out the sun, duck for cover.

Brain-Teasers in Uniform

(Answers to problems on page 89)

1. His weekly pay is $99.98.
2. 295 bombs.
3. Here is one of the possible solutions:



4. Boat D enters P. Boats A, B, and C pass P.
   Boat D goes on its way. Boats A, B, and C return to the other side of P and same operation is repeated for E and for F.
5. The two hands are together at
   12:00 Noon
   1:05½ A.M. and P.M.
   2:11 " "
   3:16½ " "
   4:22 " "
   5:27¼ " "
   6:33 " "
   7:38 " "
   8:43½ " "
   9:49 " "
   10:54½ " "
   12:00 Midnight
   134 sentries stand watch.
6. Outfit A, which receives $144. Outfit B receives only $72.
7. A man could; but a ship might not be able to. The wire would be about 16 feet above the surface of the earth.

"Maybe next year, Queenie!"

"Mallards! Gosh, don't they remind me of some swell times!

"Gets *you* kind of excited too, Queenie, doesn't it? I understand. My dog was a lot like you, and I know how he loved hunting.

"There'd be cold, gray autumn mornings when the wind almost blew our ears off. Just the right weather for ducks. I'd paddle us out to our favorite hunting place in the marsh. Pretty soon our wooden decoys would be bobbin' away, natural as life, and a big flight of mallards would start down to get chummy. Then—*whammo!*

"No matter how far away the ducks dropped, that dog of mine used to retrieve 'em every time. I'll bet you did too. And boy, what wouldn't we both give to do some duck hunting this season!

"But there's a war on now, Queenie. We're in the Coast Guard, and we've got a job to do. Maybe *next* year . . ."

* * *

Remington's job right now is to supply a lot of military arms and ammunition fast—to help speed, among other things, the return of hunters and hunting dogs to their favorite marshes. Here is what we are doing . . .

1. ***Every working day,*** *Remington produces* ***thirty million*** *rounds of military small arms ammunition.*

2. ***And, every working day,*** *Remington produces more than enough military rifles to equip an entire infantry regiment at full fighting strength.*

After the war is won, we will again be serving our sportsmen friends with Remington shotguns and rifles, Nitro Express shells, Kleanbore Hi-Speed .22's, and Core-Lokt big game bullets. *Remington Arms Company, Inc., Bridgeport, Conn.*

"Nitro Express," "Kleanbore," "Hi-Speed," "Sportsman," Reg. U.S. Pat. Off. "Core-Lokt" is a trade mark of Remington Arms Co., Inc.

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Remington Sportsman 3-shot autoloading shotgun and Nitro Express shot shells

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DU PONT

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PRECISION OPTICAL INSTRUMENTS
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•
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"I'm in a shipyard to help get my two boys home safe. That's what we're working for—to help our fighting men finish the job fast. We need your help. How about clipping that coupon right now?" *C. L. ERICKSON, Todd Foreman*

Mail to
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My occupation is_____

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Also know_____

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RE-blade to RE-sharpen

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Send at once X-ACTO I have checked. It is understood if I am not satisfied I may return within five days for refund. Also enclose FREE 32 page Manual "How To Build Model Planes".

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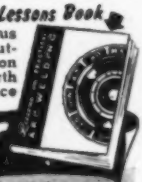

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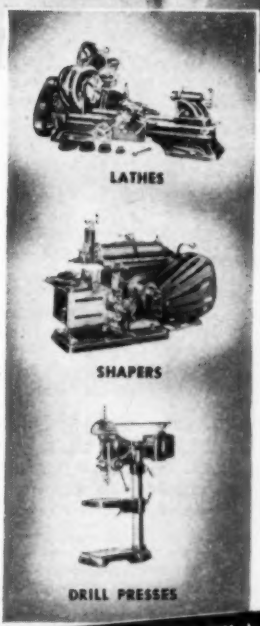

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ATLAS PRESS COMPANY

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HOW TO CHOOSE A GLUE

Don't think that there is any *one* glue that does all gluing jobs. Here are two simple rules to follow.

RULE 1 **USE CASEIN GLUE:** For all interior or protected construction—furniture, cabinets, toys, laminated trusses and beams, interior wall panels and all types of "odd jobs".

REASON: Casein Glue (CASCO) is easier, more foolproof to use than resin. CASCO is "self-bonding," needs only moderate, not extreme pressure. Has "filling action" on poorly fitted joints. Highly water-resistant, withstands any interior conditions except extreme dampness or mold. Used at any temperature (above freezing).

RULE 2 **USE RESIN GLUE:** Where a waterproof, moldproof or stainfree glue is required—boats, outdoor furniture, screens, in damp basements, on thin veneers, etc.

REASON: Resin Glue (CASCAMITE) is completely waterproof, moldproof, stainfree. (Resin glue requires well-fitted joints, smooth wood surfaces, positive clamp pressure and workroom temperature of at least 70°F.)

CASCO Powdered Casein Glue

Meets Army, Navy and Federal casein glue specifications. Highly water-resistant. Cold water mix. 10¢ to 65¢ at hardware stores.

CASCAMITE Powdered Resin Glue

The same type of glue used for Army and Navy life floats, truck bodies, other field equipment. Mixes instantly in cold water. 10¢ to 85¢ at hardware stores.

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Send me the literature checked.

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DELTA POWER TOOLS

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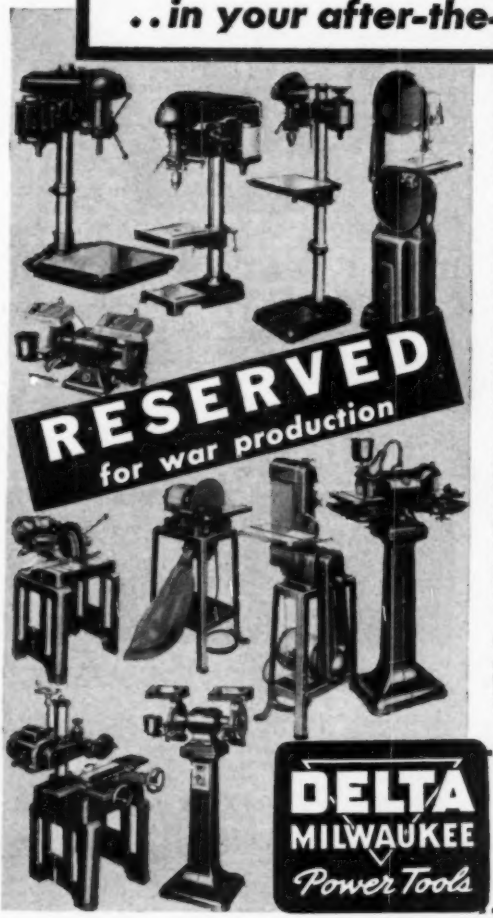

Get ready for exciting adventures in homecraft with the great new tools that are coming!

You can start today to lay the ground-work for a shop that any home craftsman might envy. A shop where you can do things you hardly thought possible — using the new Delta Power Tools that are on the way — finer, faster, safer, better-looking than *any* pre-war tools.

As we make thousands of Delta Tools for vital war work, we add to the "know-how" that has already established Delta Tools as the finest in the field. *You* get the benefits, as you create objects that are more beautiful and more saleable, and do it with greater ease, greater safety, and greater pride than ever before.

HM-4

3 things to do NOW . . .

Though Delta's entire output today is needed for war work, there are three steps you can take now to assure the maximum of enjoyment, healthful recreation, and earnings from your post-war workshop.

1. Get Delta's help in planning Below you see "How to Plan a Home Workshop," a 56-page book to help you in laying out and equipping an efficient, attractive home workshop. It's packed with practical ideas. It gives you "how to" information on dozens of subjects, from Shop Layout to Tool Racks.

Let this book help you save time and money, avoid waste of effort and materials. Use the coupon below and send for it today.

2. Build cabinets, accessories Get ready for the day of "full production." Tool racks, cabinets, storage racks and other equipment can be prepared. Use ideas from the book below.

3. Buy War Bonds with a goal Decide on the power tools you want. Then "ear-mark" your War Bond purchases and make your dollars work *two ways* for future happiness.

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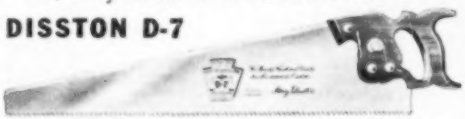
The manufacturing might of all America is concentrated on producing for victory. In the front rank of this vast industrial army are the machinists—and their weapons are tools!

In plants everywhere throughout the nation machinists are busy at every phase of their craft—helping to turn out more, faster, with tools by Disston. Some of the machinist's tools supplied to industry by Disston are the files used every day in general machine shop work, Superfine Swiss pattern files for precision work, file cards, hack saws, hack saw blades, metal cutting hand saws, metal cutting band saws, solid and inserted tooth metal cutting circular saws, metal cutting sabre blades, tool bits, machinist's chisels and others.

● If you need a hand saw for essential war work, see your Hardware Dealer about

DISSTON D-7



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What kind of "window blinds" do you want for your home after the war?

TELL US...YOU MAY WIN $200.00* IN WAR BONDS

OR ONE OF THE 41 OTHER PRIZES, TOTALING $500.00

WHAT HAS BEEN DONE

Many years ago, window drapes and shutters were used to regulate light and give privacy.

About 1864, the spring roller for cloth shades was perfected. Since then there have been few changes in this roller, or in cloth shades.

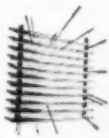
Fifteen years ago, CLOPAY perfected and introduced cellulose fiber window shades which looked like expensive cloth shades, but cost about ⅕ as much.

Then women asked: "Why can't you make a shade to attach to our old rollers so we can afford to put up fresh, clean window shades every year?" So CLOPAY invented the gummed strip which makes it easy to attach a new CLOPAY shade to an old roller—without tacks or tools. These "refill" shades still sell for 10c, 15c—with lovely washable ones for only 29c.

Next, Venetian Blinds for all. CLOPAY developed Venetians with sturdy, curved fiber slats that look like the smartest steel and wood Venetians. They cost about half as much — $1.69 to $2.19.

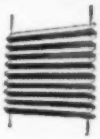
WHAT MIGHT BE DONE

For instance, you may have an idea for a window shade that pulls from side to side. Such a shade could be made.



Or, perhaps you'd like a Venetian Blind with slats of glass or some other material. Maybe you have an idea for an entirely new kind of slatted shade.

How about an accordian-type blind—one that lets down from the top, or pulls up from the bottom?



Let's have your ideas and suggestions for the window blinds CLOPAY is planning for the brighter homes of tomorrow. And even the simplest thought may win one of the 42 prizes. It may be a suggestion for a new pattern, color or material...an idea for improving wearability...a new way of hanging, pulling or adjusting. Read the easy rules and get busy this very minute.

What's your pet window shade peeve? How would you remedy it? What gets your goat about Venetian Blinds? How would you improve them? Have you a brand-new, bright idea about window blinds?

Your idea or suggestion may be the very one to win that $200.00 in War Bonds* or one of the other valuable prizes. You'll find it fun to try your hand at postwar window shade planning. And wouldn't it be grand to *win*? Sit down, write your letter, now.

CLOPAY CONTEST RULES

1st Prize .....$200 in War Bonds*
2nd Prize.....$100 in War Bonds*
Next 40 Prizes..Each, $5 in War Stamps

1. Write a letter telling us what you think is wrong with window shades or Venetian Blinds; what changes you would like after the war. Suggest, if you can, how these improvements might be made. Or briefly explain any brand-new idea you have for window blinds. Write plainly, on one side of paper only.

2. Mail your entry to Clopay Corporation, 1270 Clopay Square, Cincinnati 14, Ohio. All entries must be mailed no later than midnight, December 31, 1943.

3. Entries will be judged on the basis of originality of idea. Penmanship or fancy entries will not count extra. Decision of judges will be final. In case of ties, duplicate prizes will be awarded, but where suggestions are similar, prize will be awarded to entry explaining it most clearly and interestingly.

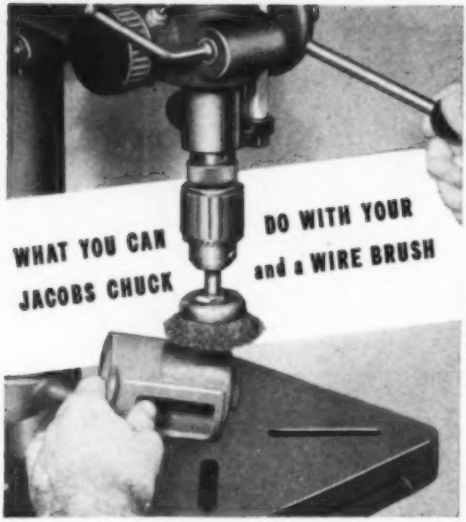
4. No entries will be returned. All entries, ideas and contents thereof become the property of the Clopay Corporation.

5. This contest is open to any resident of the United States or Canada, except employees of the Clopay Corporation or its advertising agency and their families, and is subject to all Federal, state, and local laws and regulations.

*Maturity value.

CLOPAY WINDOW SHADES

On sale at 5-&-10c and neighborhood stores everywhere.



Hard surface deposits that defy ordinary removal methods quickly give way under the harsh, scratching action of the stiff wire end brush. These brushes, held by the JACOBS Chuck in a drill press or lathe, remove rust, baked-on grease, scale, and paint.

In the photo above a small casting is being burnished. Note how the wire brush gives finish to a dull casting. With a softer brush brass, copper, and other non-ferrous metals are given a soft satiny finish.

If You Have A Drill Press or Lathe, or Are Planning on Getting One, You Will Want This Book

The operation outlined briefly here is one of nineteen covered in detail in our new booklet just off the press. It gives practical, helpful information on unusual and varied uses for drill presses and lathes. Printed in color and containing 49 illustrations, it shows how the set-ups are made, illustrates the tools used, and in some instances tells you how to make the tools themselves. If you have a workshop you will want the valuable ideas this booklet contains. If you are planning on having a shop of your own after the war, you will want the booklet now to help you plan.

10¢

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FRANKLIN *Liquid Hide* **GLUE**

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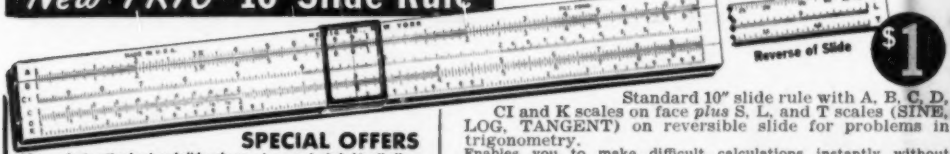

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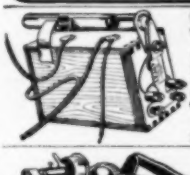

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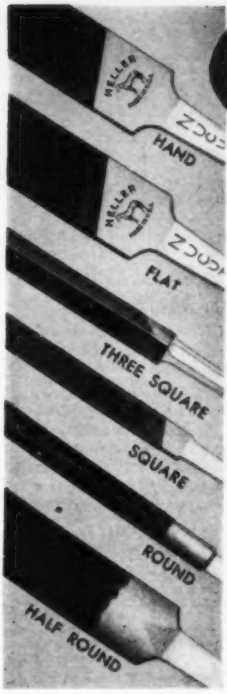

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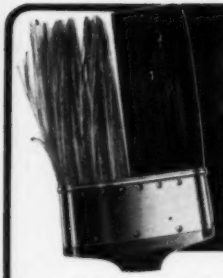

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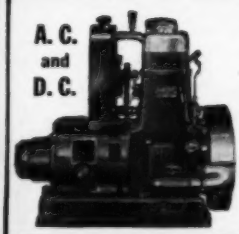

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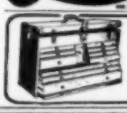

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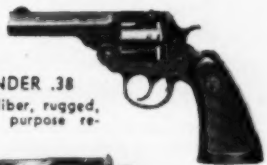

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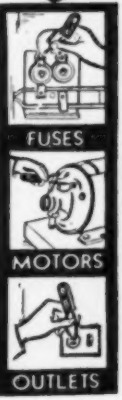

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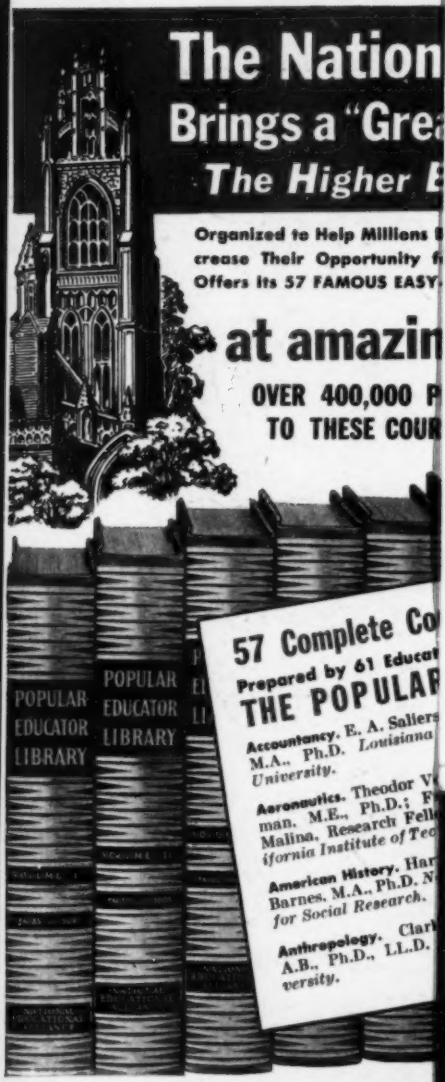
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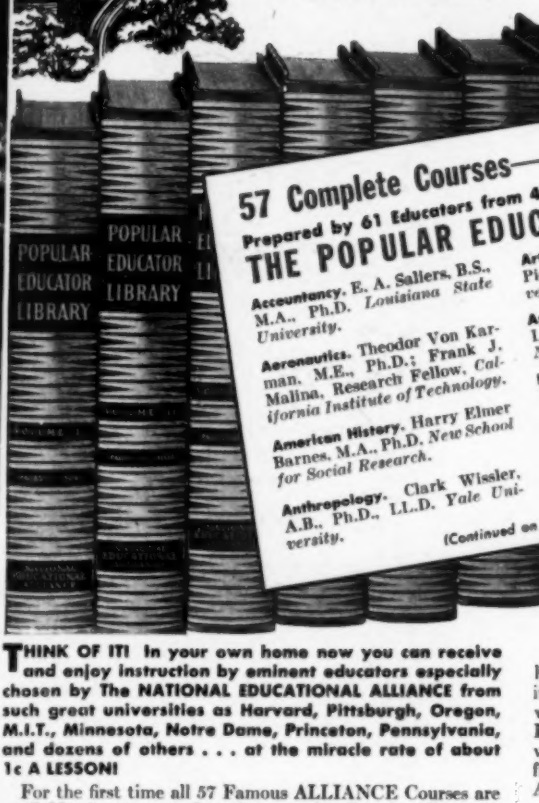

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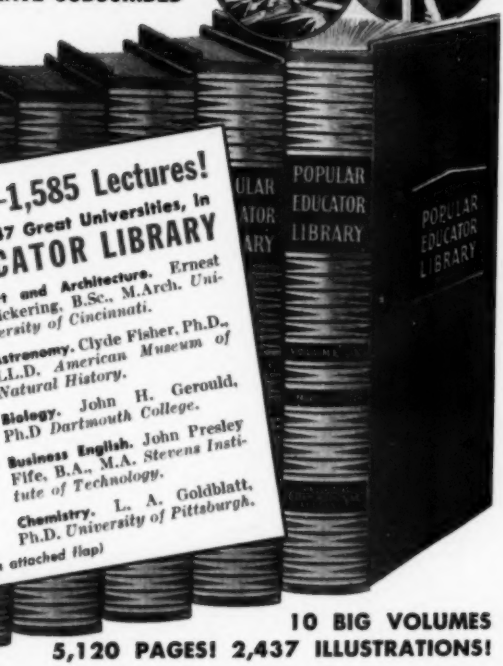

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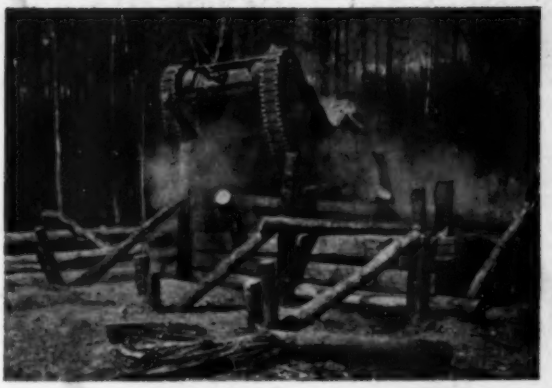

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